

Combustion Modification NO_x Controls for
Utility Boilers. Volume I: Tangential
Coal-Fired Unit Field Test

Acurex Corp.
Mountain View, CA

Prepared for

Industrial Environmental Research Lab.
Research Triangle Park, NC

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COMBUSTION MODIFICATION NO_x
CONTROLS FOR UTILITY BOILERS
Volume I. Tangential Coal-fired Unit
Field Test

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Research Triangle Park NC 27711

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16. ABSTRACT The report gives results of an environmental assessment field testing program on a tangential-coal-fired utility boiler. The aim of the program was to measure multimedia emissions changes as a result of applying combustion modification NOx control. Emissions of trace elements, organic materials, sulfur species, SO₂, NOx, CO, and particulate matter were measured. These emissions were compared under normal and low-NOx operating conditions. Source operating data were also analyzed so that changes in operating parameters and efficiency could be assessed. The tests were conducted on TVA's Kingston Steam Plant, Unit 6, a 180-MW, pulverized-coal, tangentially fired, electric utility boiler with a rated capacity of 582 Mg/hr (1.28 million lb/hr) steam. Burners-out-of-service and biased-burner firing were used for NOx control. These measures reduced NOx from baseline levels to 37% and 31%, respectively. Reduced excess air levels associated with these control methods gave a slightly improved boiler efficiency in both 5-hour tests; long-term operation under test conditions was not addressed in this program. Test results showed that NOx controls did not affect particulate or sulfur species emissions. Some changes were measured in trace element partitioning and slight increases in organic emissions with the application of NOx controls.		
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COMBUSTION MODIFICATION NO_x CONTROLS FOR UTILITY BOILERS
VOLUME I: TANGENTIAL COAL-FIRED UNIT FIELD TEST

by

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ABSTRACT

This test report describes the methods and results of an environmental assessment test program conducted at Tennessee Valley Authority's Kingston Steam Plant, Unit 6. The purpose of the test program was to measure changes in multimedia emissions as a result of applying NO_x controls. Emissions of trace elements, organic materials, sulfur species, and the criteria pollutants, SO_2 , NO_x , CO, and particulate matter, were measured. Comparisons of these emissions under normal operating conditions and controlled (for NO_x) operating conditions were then made. Source operating data were also analyzed so that changes in operating parameters and efficiency could be assessed.

Kingston Unit 6 is a 582 Mg steam per hour (1.28×10^6 lbs. steam per hour) pulverized coal tangentially fired electric utility boiler. This twin furnace, radiant, reheat, controlled circulation boiler has been in service since 1955. The medium sulfur bituminous coal fuel is mined locally in Roane County, Tennessee.

Burners out of service (BOOS) and biased (BIAS) burner firing techniques were used for NO_x control. These measures achieved NO_x reductions from baseline levels of 37 percent and 30 percent, respectively. Reduced excess air levels associated with these control

methods gave slightly improved boiler efficiencies. These were, however, 5-hour tests. Continuous operation under the test conditions was not addressed in this program.

The test program concludes that applying combustion modification NO_x controls did not affect particulate or sulfur species emissions. Some changes in trace element partitioning occurred with the application of NO_x controls. Organic material emissions increased slightly with NO_x controls.

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SECTION 1

INTRODUCTION

This report is part of a series of test reports resulting from the experimental testing task of the "Environmental Assessment of Stationary Source NO_x Control Technologies" (NO_x EA), Environmental Protection Agency (EPA) Contract 68-02-2160. The NO_x EA is a 3-year program to:

- (1) identify the multimedia environmental impact of stationary combustion sources and combustion modification NO_x controls; and
- (2) identify the most cost-effective environmentally-sound NO_x controls for attaining and maintaining current and projected NO₂ air quality standards to the year 2000.

During the first year of the NO_x EA a preliminary environmental assessment concluded that emissions and operating data needed to perform adequate process engineering and environmental assessment activities were severely lacking in several key areas. Most noteworthy was the virtual absence of data on noncriteria flue gas emissions and liquid and solid effluents (Reference 1). In response to these identified data needs, NO_x EA field test programs were initiated. Source selection was based on a source/control priority listing developed in the preliminary environmental assessment. These test programs were designed to provide information on changes in emissions and operation due to NO_x controls. The NO_x EA Field Test Program is outlined in Table 1-1.

TABLE 1-1. NO_x EA FIELD TEST PROGRAM

Source Category	Description	Test Points (Unit Operation)	Sampling Protocol	Test Collaborator	Status
Coal-fired Utility Boiler	Kingston #6; 180 MW tangential; twin furnace, 12 burners/ furnace, 3 elevations; cyclone, 2 ESP's for particulate control	Baseline Biased Firing (2) B00S (2)	Continuous NO _x , SO ₂ , CO, CO ₂ , O ₂ Inlet to 1st ESP: -- SASS -- Method 5 -- Method 8 -- Gas grab (C ₁ -C ₆ HC) Outlet of 1st ESP: -- SASS -- Method 5 -- Method 8 -- Gas grab (C ₁ -C ₆ HC) Bottom ash Hopper ash (1st ESP, cyclone) Fuel Operating data	TVA	Complete, August 1977
Coal-fired Utility Boiler	Crist #7, 500 MW opposed wall fired; 24 burners, 3 elevations; ESP for particulate control	Baseline B00S (2)	Continuous NO _x , SO ₂ , CO CO ₂ , O ₂ ESP inlet -- SASS -- Method 5 -- Method 8 -- Gas grab (C ₁ -C ₆ HC) ESP outlet -- SASS -- Method 5 -- Method 8 -- Gas grab (C ₁ -C ₆ HC) Bottom ash ESP hopper ash Fuel Operating data Bioassay	Exxon	Complete, June 1978

TABLE 1-1. Continued

Source Category	Description	Test Points (Unit Operation)	Sampling Protocol	Test Collaborator	Status
Oil-fired Utility Boiler	Moss Landing #6; 740 MW opposed wall fired; 48 burners, 4 elevations	Baseline FGR FGR + OFA	Continuous NO _x , SO ₂ , CO, CO ₂ , O ₂ SASS Method 5 Method 8 Gas grab (C ₁ -C ₆ HC) Fuel Operating data Bioassay	New test start	Scheduled, September 1978
Coal-fired Industrial Boiler	Traveling grate spreader stoker, 38 kg/s (300,000 lb/hr); ESP for particulate control; wet scrubber for SO _x control	Baseline LEA + high OFA	Continuous NO _x , SO ₂ , CO, CO ₂ , O ₂ Boiler exit: -- SASS -- Method 5 -- Shell-Emeryville -- Gas grab (C ₁ -C ₆ HC) ESP outlet -- SASS -- Method 5 -- Shell-Emeryville -- Gas grab (C ₁ -C ₆ HC) Bottom ash Cyclone hopper ash Fuel Operating data	KVB	Complete, October 1977
Coal-fired Industrial Boiler	Traveling grate spreader stoker, 25 kg/s (200,000 lb/hr) ESP for particulate control	Baseline LEA + High OFA	Continuous NO _x , SO ₂ , CO, CO ₂ , O ₂ Boiler exit: -- SASS -- Method 5 -- Shell-Emeryville -- Gas grab (C ₁ -C ₆ HC) ESP Outlet -- SASS -- Method 5 -- Shell-Emeryville -- Gas grab (C ₁ -C ₆ HC) Bottom ash ESP hopper ash Fuel Operating data Bioassay	KVB	Complete, February 1978

TABLE 1-1. Concluded

Source Category	Description	Test Points (Unit Operation)	Sampling Protocol	Test Collaborator	Status
Oil-fired Gas Turbine	T.H. Wharton Station, 60 MW GE MS 7001 C machine	Baseline Maximum water injection	Continuous NO _x , SO ₂ , CO CO ₂ , O ₂ SASS Method 5 Method 8 Fuel Water Operating data Bioassay	General Electric	Complete, April 1978
Oil-fired Residential Heating Unit	Blue Ray low NO _x furnace, Medford, New York	Continuous Cycling	Continuous NO _x , SO ₂ , CO CO ₂ , O ₂ SASS Method 5 Method 8 Fuel	New test start with EPA-RTP	Complete, 1977 November

The test program documented in this report was conducted on the Tennessee Valley Authority's Kingston Steam Plant, Unit 6. Kingston Unit 6 was selected because of its design, availability for testing, and characterization in other test programs. It is a pulverized coal tangentially fired, 180 MW electric utility boiler, producing 582 Mg steam per hour (1.28×10^6 lb steam per hour). This design is typical of a large segment of the coal-fired utility boiler population. Through the cooperation of the Tennessee Valley Authority, this unit was made available for testing in the NO_x EA Field Test Program. The Tennessee Valley Authority, under EPA co-sponsorship, conducted a trace element mass balance program and the Monsanto Research Corporation under EPA sponsorship conducted a baseline emissions study on this boiler.

The NO_x EA field test program at Kingston consisted of a baseline (normal operation) test and tests under two modes of low NO_x operation. The modes of low NO_x operation were burners out of service, (BOOS), and biased burner firing, (BIAS). The low NO_x tests were repeated for both BOOS and Bias conditions. This resulted in a test program of four low NO_x tests and one baseline test. The test program results will be used in both process analysis and source assessment modeling, conducted as part of the Environmental Assessment and Process Engineering task of the NO_x EA.

SECTION 2

TEST SITE DESCRIPTION

The unit tested was the Tennessee Valley Authority's Kingston Steam Plant, Unit 6. The Kingston Steam Plant is located on Watts Bar Lake, near Kingston, Tennessee. The plant consists of nine boiler-turbine-generator systems with a combined rated capacity (continuous) of 1440 MW electrical output. These units began commercial operation during 1954 and 1955.

Kingston Unit 6 is a pulverized coal, tangentially-fired, Combustion Engineering boiler. This boiler has a twin furnace, radiant, reheat, controlled circulation design. Each furnace has 12 coal nozzles arranged in three elevations with four nozzles at each elevation. There are six pulverizers with each pulverizer feeding a single elevation of nozzles on one furnace.

Kingston Unit 6 has a rated capacity of 582 Mg steam per hour (1.28×10^6 lbs steam per hour) with a 4-hour maximum capacity of 641 Mg steam per hour (1.41×10^6 lbs steam per hour). These ratings correspond to 180 and 200 MW generator output, respectively.

Flue gas cleaning equipment consists of a mechanical collector, a low efficiency electrostatic precipitator (ESP), and a high efficiency ESP. Each furnace has its individual particulate removal equipment. Originally, each unit exhausted into its own 91 m (300 ft.) stack. With

the addition of the high efficiency ESP, two 274 m (900 ft.) stacks were erected to serve the entire Kingston Steam Plant. Figures 2-1 through 2-3 show the arrangement of boiler and flue gas particulate removal systems.

The testing was conducted on one furnace of the twin furnace design. The arrangement of the fuel, air, ash, and flue gas handling systems made it possible to control the operation and collect effluent samples from one furnace with no interference from the second furnace. The sampling locations are discussed in Section 3.

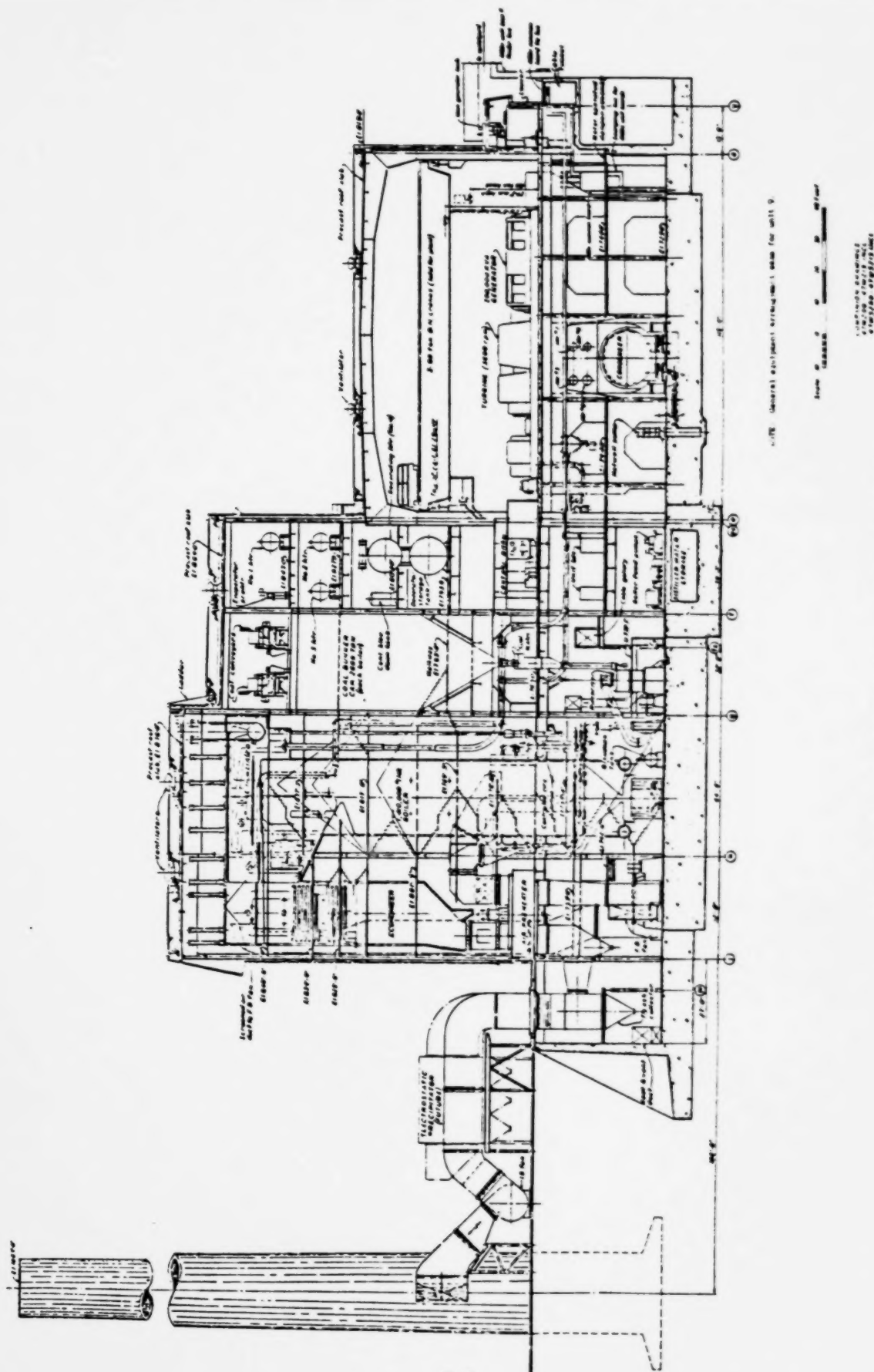


Figure 2-1. Equipment transverse section.

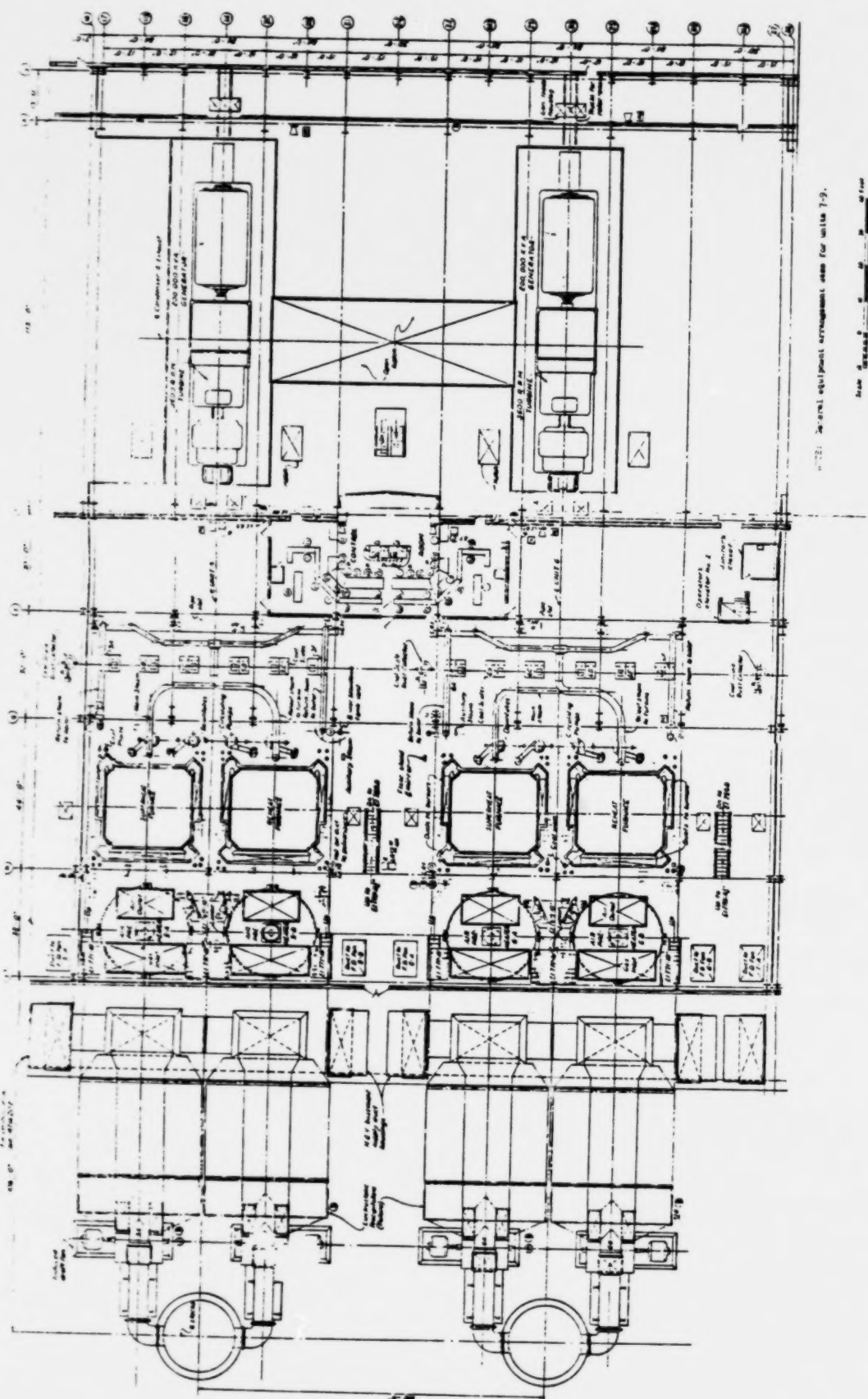


Figure 2-2. Equipment plan view.

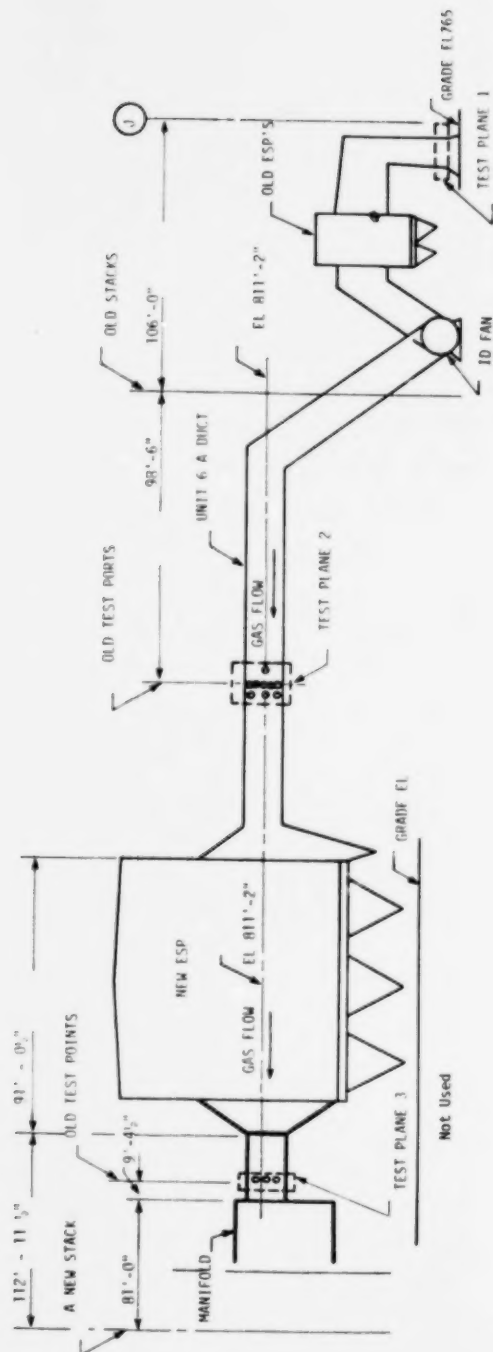


Figure 2-3. Arrangement of precipitators and stacks.

SECTION 3

TEST PLAN

The objective of this test program was to examine incremental changes in emissions and process operations as a result of combustion modification NO_x controls. In order to assess incremental changes in emissions it was necessary to consider all influent and effluent streams. Process data were recorded periodically during each test so that changes in process operation could be examined.

3.1 UNIT OPERATION

The test program at Kingston examined incremental changes in emissions and operation at three levels of NO_x control. A baseline, "as found," test represented the uncontrolled (for NO_x) level. Biased burner firing (Bias), an intermediate level of NO_x control, consisted of firing the two lower elevations of fuel nozzles at higher fuel/air ratios than the top elevation. Burners out of service (BOOS), in which the top elevation of fuel nozzles admitted air only while the lower elevations admitted fuel at greater than baseline rates, represented the highest degree of NO_x control.

Key operating parameters were held constant during the entire test program to simplify comparisons between tests. The tests were conducted at the same unit load under the three firing conditions. This load was the maximum load obtained with one elevation of fuel nozzles of one

furnace admitting air only. This corresponded to a generator output of 177 MW. In the twin furnace design, a decrease in the firing rate of one furnace may be compensated by an increase in the firing rate of the other furnace. This resulted in slight variations in individual furnace firing rates from one test to another. Other parameters held constant throughout the test program were steam flowrate, steam temperature, steam pressure, burner tilt and heat input to the furnace being monitored (to within 5 percent). The continuous blowdown valves were closed during the tests.

During each test, unit operation was to remain unchanged. Airflow, pulverizer feedrates, and air damper settings were not altered. Soot blowing cycles were completed prior to the start of each test and were not started again until the end of the test. Any steam temperature control was accomplished using attemperation. Bottom ash was pulled prior to each test and again near the end of the test. This ensured the sampling of ash collected during the test period only.

The tests at Kingston were conducted in August and September 1977. Due to system demand, Kingston Unit 6 was run at a peak output of 200 MW during the day. Since these tests required a unit load of 177 MW, all testing was performed during off-peak hours. Generally, the testing started around 1 a.m. and ended around 8 a.m. The test program schedule is given in Table 3-1. By testing in this schedule of one test each day the effects of variations in coal supplies were minimized and prolonging the test program due to forced equipment outages was avoided.

3.2 SAMPLING AND ANALYSIS

The sampling and analysis procedures used in this test program conform to a modified EPA Level 1 protocol. The purpose of these screening procedures is "to obtain preliminary environmental assessment

TABLE 3-1. TEST PROGRAM SCHEDULE

August 26, 1977	Preliminary Measurements
August 27, 1977	B00S I
August 28, 1977	Bias I
August 29, 1977	Baseline (Test not completed due to coal pulverizer failure)
August 30, 1977	Baseline
August 31, 1977	B00S II
September 1, 1977	Bias II

information, identify problem areas, and provide the basis for the prioritization of streams, components, and classes of materials for further consideration in the overall assessment. As such, the results of the sampling and corresponding analysis procedures are quantitative within a factor of ± 2 to 3" (Reference 2).

The modifications to the Level 1 protocol are listed below:

- Atomic absorption spectroscopy for selected trace elements instead of spark source mass spectrometry
- Specific ion electrodes for selected anions and ammonium ion instead of test kits
- Gas chromatograph/mass spectrometer for identification and quantitation of polynuclear organic materials (POM) instead of low resolution mass spectrometry.

These modifications were used to improve the quantitative aspects of the analyses. The methods used for particulate, sulfur species, and the

continuous monitors for NO_x , O_2 , CO , CO_2 , and SO_2 are also more quantitative than the Level 1 screening procedures for trace species.

3.2.1 Sampling

In order to evaluate incremental changes in emissions, all influent and effluent streams must be analyzed. In this test program, all of these streams, with the exception of ambient air, were sampled and analyzed.

The following samples were collected:

- Coal
- Bottom ash (slurry)
- Bottom ash sluice water
- Mechanical collector ash
- Low efficiency ESP ash
- Flue gas
- Continuous monitors NO_x , SO_x , CO , CO_2 , O_2 upstream of airheater
- Source Assessment Sampling System (SASS) and combined EPA Method 5 (particulate) and EPA Method 8 (sulfur species) at the inlet to the low efficiency ESP
- SASS and combined EPA Method 5 and Method 8 at the outlet of the low efficiency ESP.

A schematic showing sampling point locations is given in Figure 3-1. Descriptions of the sampling methods are given in the following paragraphs. Since each test required several hours to perform, it was important that the methods obtain samples representative of the entire test.

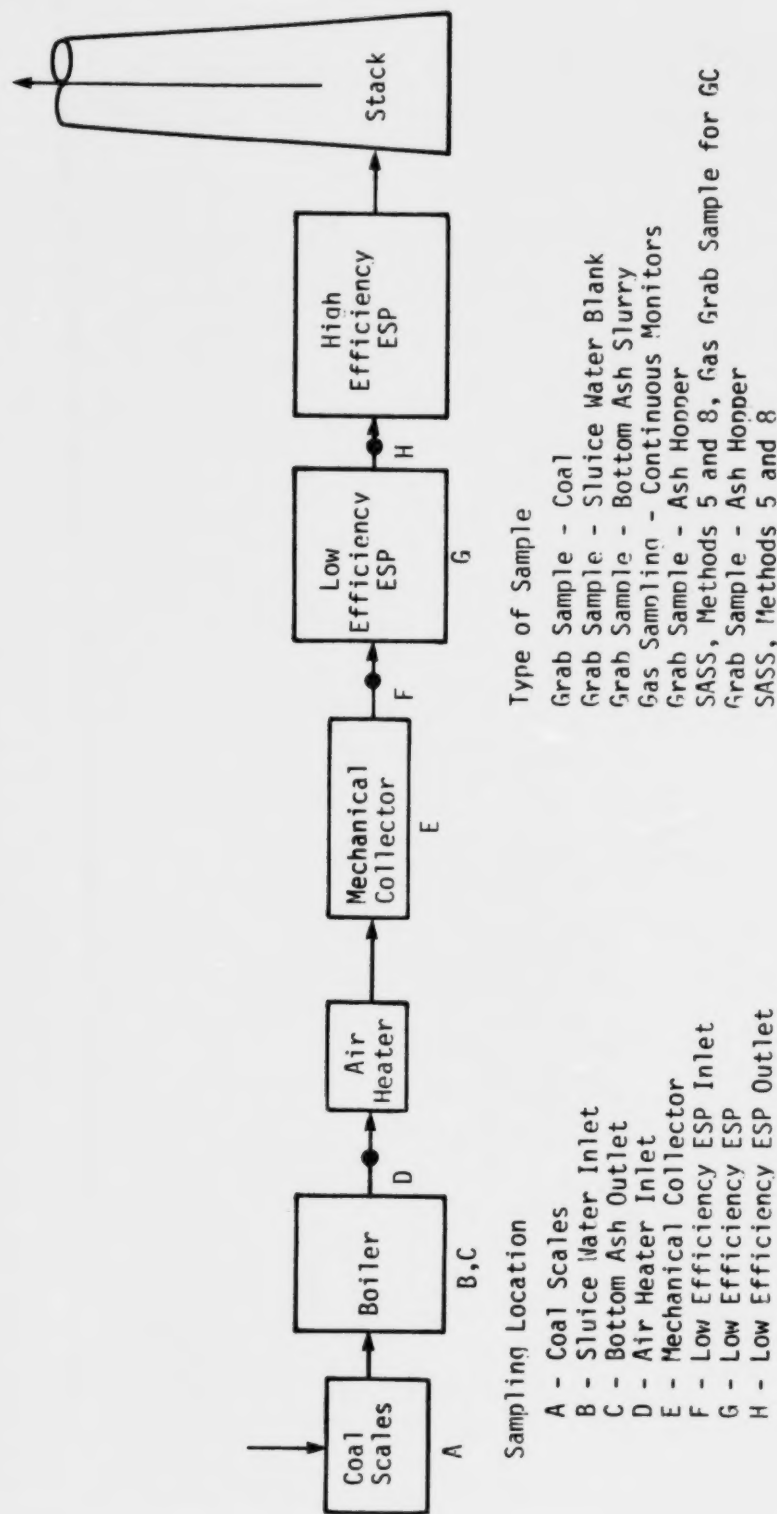


Figure 3-1. Sampling locations.

Coal Samples

Coal samples were collected from each coal feeder serving the furnace system being characterized. A grab sample from each coal feeder was collected at 15-minute intervals during the test. This composite sample was then ground and mixed with a representative sample being extracted.

Bottom Ash

Immediately prior to the test, bottom ash was removed from the boiler. At the end of the test, bottom ash was removed again. This ensured that the bottom ash sample would come from the test period. The bottom ash was removed by a water sluice system. During the process, dipper sampling was used to obtain a composite bottom ash slurry sample. A sample of the sluice water inflow was also obtained for comparison.

Flue Gas Continuous Monitors

The continuous monitors for flue gas analysis were furnished by TVA in their mobile sampling van. The gas samples were taken from three points in the ductwork between the boiler outlet and the air heater inlet; and were taken continuously during each test. A description of the instrumentation in the TVA sampling van is given in Table 3-2.

Flyash

Flyash collected by the mechanical collector and the low efficiency electrostatic precipitator were sampled periodically during each test. These samples were taken from the collector hoppers each time the vacuum ash removal system cycled.

Particulate and Sulfur Species

Combined EPA Methods 5 and 8 sampling trains using Acurex High Volume Stack Sampler (HVSS) systems were used to obtain particulate

loading and sulfur species concentrations at the inlet and outlet of the low efficiency electrostatic precipitator. The sulfur species determined were gaseous SO_2 and SO_3 and particulate sulfate ($\text{SO}_4=$).

Source Assessment Sampling System

Two Source Assessment Sampling System (SASS) trains were used simultaneously to sample the flue gas entering and leaving the low efficiency electrostatic precipitator. These samples were used for trace element and organic species determinations in both vapor and condensed phases and also to provide particulate size distribution and trace element partitioning information.

The SASS train extracts the following samples:

- Particulate: $>10\ \mu\text{m}$, $3-10\ \mu\text{m}$, $1-3\ \mu\text{m}$, $1\ \mu\text{m}$
- Vapor phase: XAD-2 porous polymer resin sorbent cartridge
- Aqueous condensate
- Hydrogen peroxide impinger
- Ammonium persulfate-silver nitrate impingers

A schematic of the SASS train is shown in Figure 3-2. The analysis protocol is given in Appendix B.

C₁-C₆ Hydrocarbons

A gas grab sample was collected at the inlet to the low efficiency electrostatic precipitator. The sample was collected in a Tedlar bag and then used to determine C₁-C₆ hydrocarbon compounds by using an onsite gas chromatograph. A Carle model 8500 portable gas chromatograph with flame ionization detector was used for this analysis.

TABLE 3-2. CONTINUOUS MONITORS IN TVA SAMPLING VAN

Instruments	Technique	Measuring Range
1. NO, NO _x Analyzer Thermo Electron Model 10A	Chemiluminescent, negative pressure	0-10 ppm 0-25 ppm 0-100 ppm 0-250 ppm 0-1000 ppm 0-2500 ppm
2. CO Analyzer Beckman No. 864	nondispersive infrared absorption	0-1000 ppm 0-5000 ppm
3. CO ₂ Analyzer Beckman No. 864	nondispersive infrared absorption	0-5 % 0-20 %
4. SO ₂ Analyzer DuPont No. 400	nondispersive ultraviolet absorption	0-1000 ppm 0-5000 ppm
5. O ₂ Analyzer Beckman (742 Model)	polarographic sensor	0-5 % 0-10 % 0-25 %
6. Hydrocarbon Analyzer Beckman No. 400	flame ionization	0-1000 ppm 5-100,000 ppm

3.2.2 Analysis

Table 3-3 lists the analyses performed on the data and samples collected during each test. Descriptions of these analyses are given in the following paragraphs. In cases of replicate tests, not all analyses were performed on all of the samples. Organic analyses were completed for the Baseline and BOOS II tests, giving changes in organic material emissions for the uncontrolled and controlled (for NO_x) conditions.

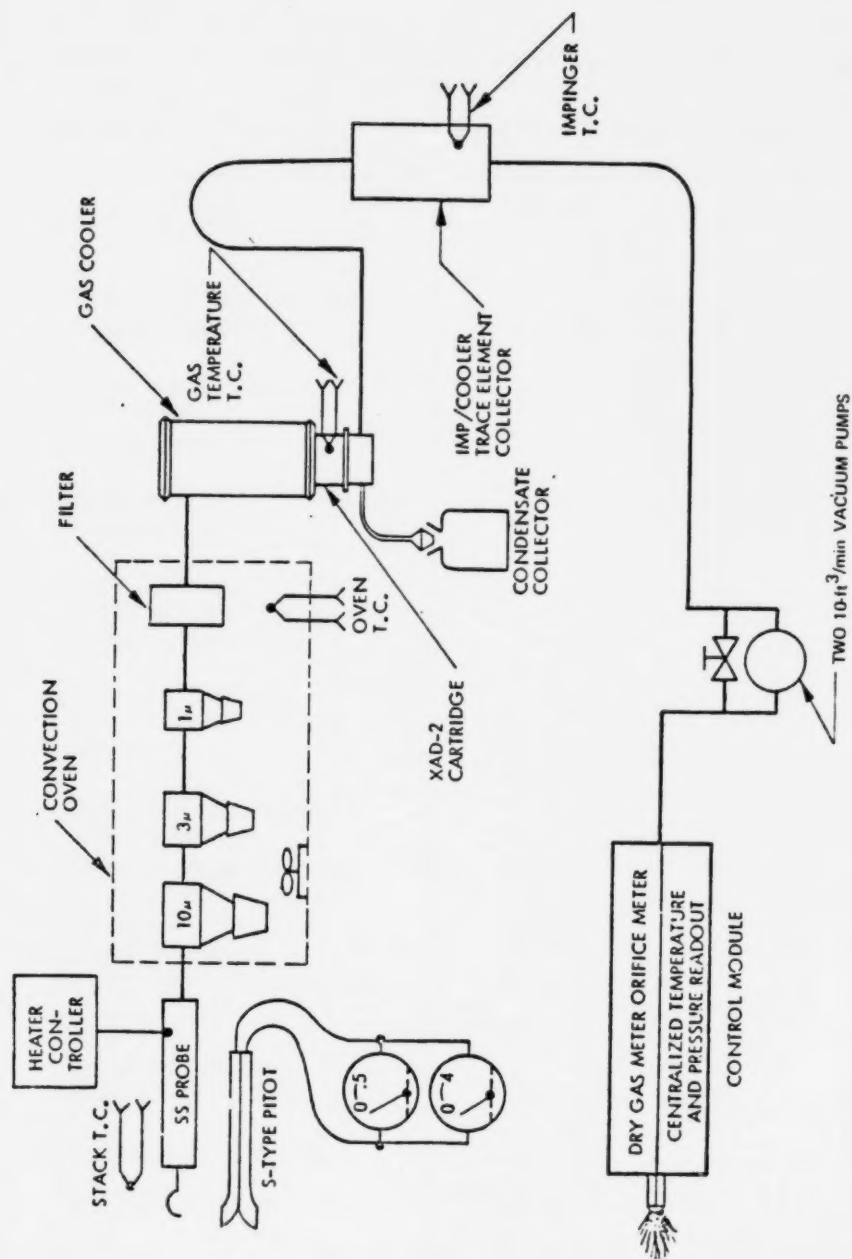


Figure 3-2. Source assessment sampling system (SASS) schematic (Reference 3).

TABLE 3-3. DATA AND SAMPLE ANALYSIS SCHEDULE

Analysis \ Test	Baseline	BOOS I	BOOS II	BIAS I	BIAS II
Operating Data	X	X	X	X	X
Fuel					
Proximate and Ultimate	X	X	X	X	X
Trace Elements	X	X	X	X	X
Bottom Ash Sluice					
Water Blank					
Trace Elements	X	X	X	X	
Bottom Ash Slurry Filtrate					
Trace Elements	X	X	X	X	
Bottom Ash Solids					
Trace Elements	X	X	X	X	
Organic Material	X		X		
Bottom Ash Slurry					
BOD	X	X	X	X	X
COD	X	X	X	X	
Mechanical Collector					
Trace Elements	X	X	X	X	
Organic Material	X		X		
SASS Train ESP Inlet					
Trace Elements	X ¹	X ¹	X ¹	X ¹	X ¹
Methods 5/8 ESP Inlet	X	X	X	X	X
ESP Ash					
Trace Elements	X	X	X	X	
Organic Material	X		X		
SASS Train ESP Outlet					
Trace Elements	X	X ²	X	X ²	X ²
Organic Material	X		X		
Methods 5/8 ESP Outlet	X	X	X	X	X
Flue Gas					
NO _x , CO, CO ₂ , O ₂ ,	X	X	X	X	X
SO ₂ , C ₁ - C ₆	X		X	X	X

1 - No XAD-2 analysis for trace elements

2 - XAD-2 analysis for trace elements not complete

Operating Data Analysis

The unit operating data collected during each test was used to calculate unit efficiency and to verify that unit operating parameters were being maintained according to the test plan. The average values for the operating parameters are given in Appendix A. Since much of the panel board data was taken from instrumentation which had not recently been calibrated, these values should be regarded as relative rather than absolute. Unit efficiency was calculated using the Heat Loss Method, ASME Abbreviated Efficiency Test (Reference 5). Results of these calculations are given in Appendix A.

Inorganic Analyses

Trace element analyses for 25 selected trace elements were performed on fuel, bottom ash, mechanical collector hopper ash, ESP hopper ash, SASS flyash, and SASS impinger solutions. The procedure used for each trace element is outlined in Appendix B, "Elemental Analysis Flowsheet." Ash samples were also analyzed for selected anions; chloride, fluoride, nitrate, cyanide, and sulfate, plus ammonium as outlined in Appendix B, "Anions Plus Ammonia Analysis Flowsheet." Proximate and ultimate analyses were conducted on the fuel samples. Flyash was examined for unburned combustible material.

Organic Analyses

Organic analyses were performed in accordance with the EPA Level 1 protocol (References 2 and 4). The analyses included flue gas C_1-C_6 hydrocarbons, organic material condensed on the ash samples, and organic material caught in the XAD-2 sorbent trap or retained in the condensate trap. In addition to the above analyses, biological oxygen demand and chemical oxygen demand analyses were performed on the bottom ash slurry samples. An outline of the organic analyses procedures is given in Appendix B.

SECTION 4

TEST PROGRAM RESULTS

Data from the test program provided information on unit operation, flue gas composition, particulate emissions, trace element emissions, sulfur species emissions, and organic material emissions. Data obtained are discussed in the report sections that follow.

4.1 UNIT OPERATION

Unit operation was held essentially constant throughout each test. Key operating variables were controlled throughout the test program so that tests could be compared to each other. A summary of the boiler operating conditions is given in Table 4-1. Detailed control room data for each test are presented in Appendix A. The data presented in Appendix A are average values of the data recorded on 15-minute intervals during the test program.

The unit load for the test program was the maximum load that could be maintained in the burners out of service (BOOS) firing configuration. This load corresponded to 177 to 178 MW electrical generator output. This value is based on total unit output. The boiler tested was a twin furnace design and a reduced firing rate in one furnace could be compensated by an increased firing rate in the other furnace. Heat input to the furnace being tested was held to within ± 5 percent of the average heat input for the entire program.

TABLE 4-1. FURNACE "A" OPERATING CONDITIONS

Test	Unit Load MW	Coal Flow kg/s (ton/hr)	Heat Input MW (10 ⁶ Btu/hr)	Flue Gas Flow ^a scm/MJ (scf/ 10 ⁶ Btu)	Excess Air (Percent)
Baseline	178	8.66 (34.3)	227 (774)	0.3530 (13190)	31
B00S No. I	177	7.70 (30.5)	206 (704)	0.4043 (15060)	23
B00S No. II	178	7.93 (31.4)	210 (716)	0.3798 (14150)	25
Bias No. I	177	8.71 (34.5)	229 (782)	0.3495 (13020)	28
Bias No. 2	178	7.98 (31.7)	227 (776)	0.3083 (11480)	24

^aEsp Inlet

NO_x control consisted of altering the coal and air flowrates to the different elevations of fuel and air nozzles and also lowering the total excess air. Excess air ranged from a baseline value of 31 percent to a BOOS I value of 23 percent with intermediate values for Bias I - 28 percent, BOOS II - 25 percent, and Bias II - 24 percent. Figure 4-1 shows the air register settings and heat input for the different firing arrangements.

Analysis results for the coals used during the test program are given in Table 4-2. Although the coals fired for each test were very similar in composition, some day to day variations were encountered. For example, nitrogen content varies from 1.38 to 1.13 percent. Sulfur content varies over a similar range from 2.4 to 1.75 percent.

Operating problems such as excessive slagging in the furnace or ash accumulation on the convective surfaces were not evident during the test program. It must be realized, however, that these tests were of 5 to 6 hours duration and can hardly be indicative of extended operation.

Boiler efficiency for each of the tests was calculated using the abbreviated ASME efficiency method (Reference 5). The calculation results are given in Table 4-3; details are given in Appendix A.

As mentioned previously, during low NO_x firing, the coal and air flowrates to the top elevation of fuel and air nozzles were adjusted so that either the coal flow to these burners was stopped (BOOS) or reduced (Bias). As Table 4-3 shows, the heat input for the Bias testing was very close to the baseline value, however, BOOS firing forced the heat input to decrease by about 10 percent of the baseline value. For each test point the degree of excess air reduction attainable was dependent on acceptable levels of CO emissions. Excess air was lowered until further reduction



Air Register Settings (percent open)

Test	Baseline				B00S				Bias			
Corner	a	b	c	d	a	b	c	d	a	b	c	d
Air Register												
1	100	100	100	100	40	40	40	40	100	100	100	100
2	100	100	100	100	20	20	20	20	100	100	100	100
3	20	20	20	20	20	20	20	20	20	20	20	20
4	100	100	100	100	50	50	50	50	50	50	50	50
5	20	80	20	20	20	80	20	20	20	80	20	20
6	100	100	100	100	50	50	50	50	50	50	50	50
7	100	100	100	100	50	50	50	50	20	20	20	20

Heat Input by Fuel Elevation MW, (10^6 Btu/hr)¹

Test Fuel Elevation	Baseline	B00S I	B00S II	Bias I	Bias II
1	75.6 (258)	0	0	22.9 (78)	44.8 (153)
2	78.2 (267)	95.8 (327)	94.1 (321)	97.6 (333)	83.8 (286)
3	73.0 (249)	110.5 (377)	115.7 (395)	108.7 (371)	98.7 (337)
Total	226.8 (774)	206.3 (704)	209.8 (716)	229.2 (782)	227.3 (776)

¹Based on high heating value at constant volume.

Figure 4-1. Air register settings and heat input.

TABLE 4-2. COAL ANALYSIS (PERCENT BY WEIGHT)

	Baseline	BOOS I	BOOS II	Bias I	Bias II
<u>Ultimate Analyses</u>					
Moisture	2.04	1.58	2.58	2.34	1.97
Carbon	63.13	64.45	64.00	63.46	68.33
Hydrogen	4.27	4.39	4.28	4.24	4.62
Nitrogen	1.38	1.13	1.38	1.13	1.02
Chlorine	0.55	0.05	0.03	0.02	0.01
Sulfur	2.19	2.40	2.13	1.75	1.75
Ash	19.60	19.26	18.49	19.09	14.59
Oxygen (diff)	6.84	6.74	7.11	7.97	7.71
<u>Proximate Analyses</u>					
Moisture	2.04	1.58	2.58	2.34	1.97
Ash	19.60	19.26	18.49	19.09	14.59
Volatile	31.84	32.10	31.68	31.86	33.32
Fixed Carbon	46.52	47.06	47.25	46.71	50.12
HHV J/g (Btu/lb)	36,288 (11,302)	26,854 (11,545)	26,521 (11,402)	26,363 (11,334)	28,484 (12,246)

TABLE 4-3. BOILER EFFICIENCY

	Baseline	BOOS I	BOOS II	Bias I	Bias II
Heat Input (percent baseline)	100	91	92	101	101
Excess O ₂ (percent baseline)	100	78	85	91	82
Efficiency (percent)	86.52	87.28	86.84	86.59	87.05
Heat Loss due to Combustibles in Flyash (percent)	0.70	0.54	0.71	0.75	0.59
Heat Loss due to Dry Flue Gas (percent)	6.79	6.26	6.44	6.70	6.39

caused significant increases in CO emissions. As noted in Table 4-3, low NO_x firing modifications seem to have either little effect on furnace efficiency (Bias I) or a positive effect causing an increase in efficiency of up to about 0.8 percent (BOOS I). The increase in operating efficiency is due to decreased excess air. Ash analyses showed that low NO_x firing had no significant effect on the amount of combustible material in the ash.

4.2 FLUE GAS COMPOSITION

Table 4-4 lists the results obtained from gas sampling at the boiler outlet. As expected, NO_x levels decreased for the Bias and BOOS firing modes. Levels of NO_x for the Bias tests decrease to about 70 percent of the Baseline emissions. In the BOOS tests, NO_x levels are reduced to about 63 percent of the Baseline value.

Emissions of SO₂ appear to be unaffected by NO_x controls. Changes in SO₂ emissions generally follow changes in the level of sulfur in the coal fired for each test. However, the high sulfur level for the BOOS I coal appears to be unrepresentative when SO₂ and coal sulfur levels are compared. Sulfur species emissions are treated further in Section 4.5.

The effects of NO_x controls on CO emissions cannot readily be assessed in this study. NO_x controls were applied until CO excursions were noted. In each test there was a threshold O₂ level, below which CO excursions took place. Once the threshold level was determined, the excess air level was increased to provide a comfortable operating margin. Thus, in all cases, CO was maintained at a low level. The CO levels measured are given in Table 4-4.

4.3 PARTICULATE EMISSIONS

Particulate emissions were measured simultaneously at both the inlet and the outlet of the low efficiency ESP. These measurements were

TABLE 4-4. FLUE GAS COMPOSITION

	Baseline	B00S I	B00S II	Bias I	Bias II
O ₂ (percent dry)	5.18	4.06	4.40	4.71	4.25
CO ₂ (percent dry)	13.87	14.79	14.56	14.39	14.73
H ₂ O (percent)	8.23	7.17	9.28	9.61	8.63
CO (ppm @ 3% O ₂ dry) % Baseline	28.6 100	31.9 112	21.7 76	35.0 122	24.7 86
NO _x (ppm @ 3% O ₂ dry) % Baseline	490 100	311 63	304 62	336 69	341 70
SO ₂ (ppm @ 3% O ₂ dry) % Baseline	2059 100	1893 92	1865 91	1527 74	1612 78

obtained by using EPA Method 5 and SASS techniques. EPA Method 5 employs multipoint equal area sampling to measure particulate concentration. The SASS train is used primarily to obtain samples for trace specie analysis. In doing this, the SASS train provides particulate concentration and size distribution data from a single point sample. Since this single point is a point of average flue gas velocity, the SASS sample is representative of the duct content. Simultaneous sampling at both the inlet and the outlet of the ESP will give the following information:

- Particulate concentration at the inlet and outlet of the low efficiency ESP
- ESP collection efficiency
- Particulate size distribution at the inlet and outlet of the ESP

Comparisons of these data will show the effects of low NO_x firing on particulate concentration, size distribution, and ease of collection.

Particulate concentration data from both the EPA Method 5 and SASS sampling trains are presented in Tables 4-5 and 4-6. The particulate concentrations are reported on a heat input basis ($\mu\text{g}/\text{J}$). The ESP inlet concentration is also reported on a normalized basis (g flyash/g ash in coal) by dividing by the coal ash content ($\mu\text{g}/\text{J}$). The particulate concentrations obtained by Method 5 sampling appear to exhibit some inconsistencies. These apparent anomalies occur in the inlet concentrations of the BOOS I and Bias II tests. ESP inlet dust loadings recorded during these tests appear too low. Values of about $0.56 \mu\text{g}/\text{J}$ were obtained during these tests compared to values of approximately $1.3 \mu\text{g}/\text{J}$ obtained in the Baseline, BOOS II and Bias I tests. The SASS particulate concentrations also suggest an error is present in the Method 5 BOOS I and Bias II inlet dust loadings.

TABLE 4-5. METHOD 5 PARTICULATE CONCENTRATION ($\mu\text{g}/\text{J}$)

	Baseline	B00S I	B00S II	Bias I	Bias II
ESP Inlet	1.407	0.578	1.232	1.373	0.551
ESP Outlet	0.228	0.265	0.160	0.238	0.155
ESP Collection Efficiency (percent)	83.8	54.2	87.0	82.7	71.9
Inlet ^a Concentration ($\mu\text{g}/\mu\text{g}$)	0.189	0.080	0.176	0.189	0.096

TABLE 4-6. SASS PARTICULATE CONCENTRATION ($\mu\text{g}/\text{J}$)

	Baseline	B00S I	B00S II	Bias I	Bias II
ESP Inlet	1.935	1.833	1.741	1.557	1.065
ESP Outlet	0.243	0.079	0.261	0.250	0.102
ESP Collection Efficiency (percent)	87.4	95.7	85.0	83.9	90.4
Inlet ^a Concentration ($\mu\text{g}/\mu\text{g}$)	0.259	0.255	0.249	0.214	0.186

^a(g flyash/g coal ash) Computed by dividing inlet concentration ($\mu\text{g}/\text{J}$) by coal ash content ($\mu\text{g}/\text{J}$)

Noting BOOS I and Bias II inlet particulate concentrations as exceptions, Table 4-5 shows that the normalized inlet concentration (g flyash/g coal ash) remains fairly constant for the various firing modes. Particulate concentration at the ESP inlet is slightly lower for the BOOS II test than for the Baseline and Bias I tests. The SASS data in Table 4-6 substantiate this observation and also indicate reduced particulate concentrations from the Baseline level for the Bias tests.

The collection efficiency of the ESP, by weight, can be determined by comparison of particulate loadings at the inlet and outlet of the ESP. Since the Method 5 sampling employs a multipoint traverse, its results should be more accurate than the single point SASS results. Noting the ESP inlet BOOS I and Bias II tests as exceptions, the Method 5 results in Table 4-5 show that collection efficiency improves slightly with the burners out of service firing mode in the BOOS II test. There is little difference in collection efficiency between the Baseline and Bias I tests. The SASS data in Table 4-6 show collection efficiencies both higher and lower than the Baseline level for both BOOS and Bias tests.

Particulate size distributions at the ESP inlet and outlet are given in Tables 4-7 and 4-8 respectively. These data were obtained by using the weights of the particulate collected in the SASS train cyclones. The SASS train cyclones have nominal cut diameters of 10, 3, and 1 microns. Submicron particles are collected by a filter. Due to equipment malfunctions, the complete set of cyclones was not available for all tests as evidenced by the absence of some data in Tables 4-7 and 4-8.

The particulate size distributions given in Tables 4-7 and 4-8 can be used to yield the mean diameters of the particulate entering and leaving the ESP. The aerodynamic cut diameters of the individual SASS

TABLE 4-7. SASS TRAIN PARTICULATE SIZING (CUMULATIVE WEIGHT PERCENT OVERSIZE) INLET TO ESP

	Baseline	B00S I	B00S II	Bias I	Bias II
10 μ m Cyclone	36.83	30.51	35.44	95.08	94.54
3 μ m Cyclone	77.15	82.89	77.50		
1 μ m Cyclone	95.23	98.31	95.09		
Filter	100	100	100	100	100

TABLE 4-8. SASS PARTICULATE SIZING (CUMULATIVE WEIGHT PERCENT OVERSIZE) OUTLET OF ESP

	Baseline	B00S I	B00S II	Bias I	Bias II
10 μ m Cyclone	16.71	--	--	15.99	23.41
3 μ m Cyclone	40.59	--	--	57.08	56.14
1 μ m Cyclone	68.71	--	--	90.03	81.51
Filter	100	100	100	100	100

cyclones have been determined, from previous testing, to be 9.7, 3.7, and 1.5 microns. These cut diameters are based on a collection efficiency of 50 percent (Reference 6). The resulting size distributions are shown in Figures 4-2 and 4-3.

Figure 4-2 shows similar particulate size distributions at the inlet to the ESP for the Baseline, BOOS I, and BOOS II tests. The aerodynamic mean diameter is shown to be 7.2 microns for each of the three tests. Figure 4-3 shows aerodynamic mean diameters at the ESP outlet of 2.8, 4.2, and 4.2 microns for the Baseline, Bias I, and Bias II tests. Particle size distribution indicates larger particulate at both the ESP inlet and outlet in the biased burner firing tests. A summary of the particle size distribution figures is given in Table 4-9.

In summary, the data from the particulate tests showed that: Biased burner firing resulted in larger particle size than either burners out of service or baseline firing conditions. ESP collection efficiency showed a slight improvement in the burners out of service firing mode. There was little difference in collection efficiencies between the Baseline and Bias tests.

4.4 TRACE ELEMENT CHARACTERIZATION AND EMISSIONS

Samples taken at the various sampling locations shown earlier in Figure 3-2 were analyzed for selected trace elements and ionic species. The samples collected and analyzed were coal, bottom ash slurry and sluice water inflow, mechanical collector hopper ash, flue gas at the inlet to the low efficiency ESP, ESP hopper ash, and flue gas at the ESP outlet. The flue gas was sampled by using a SASS train. Grab samples were taken periodically from the other streams during the SASS test period. The detailed results of these analyses are presented in Appendix C.

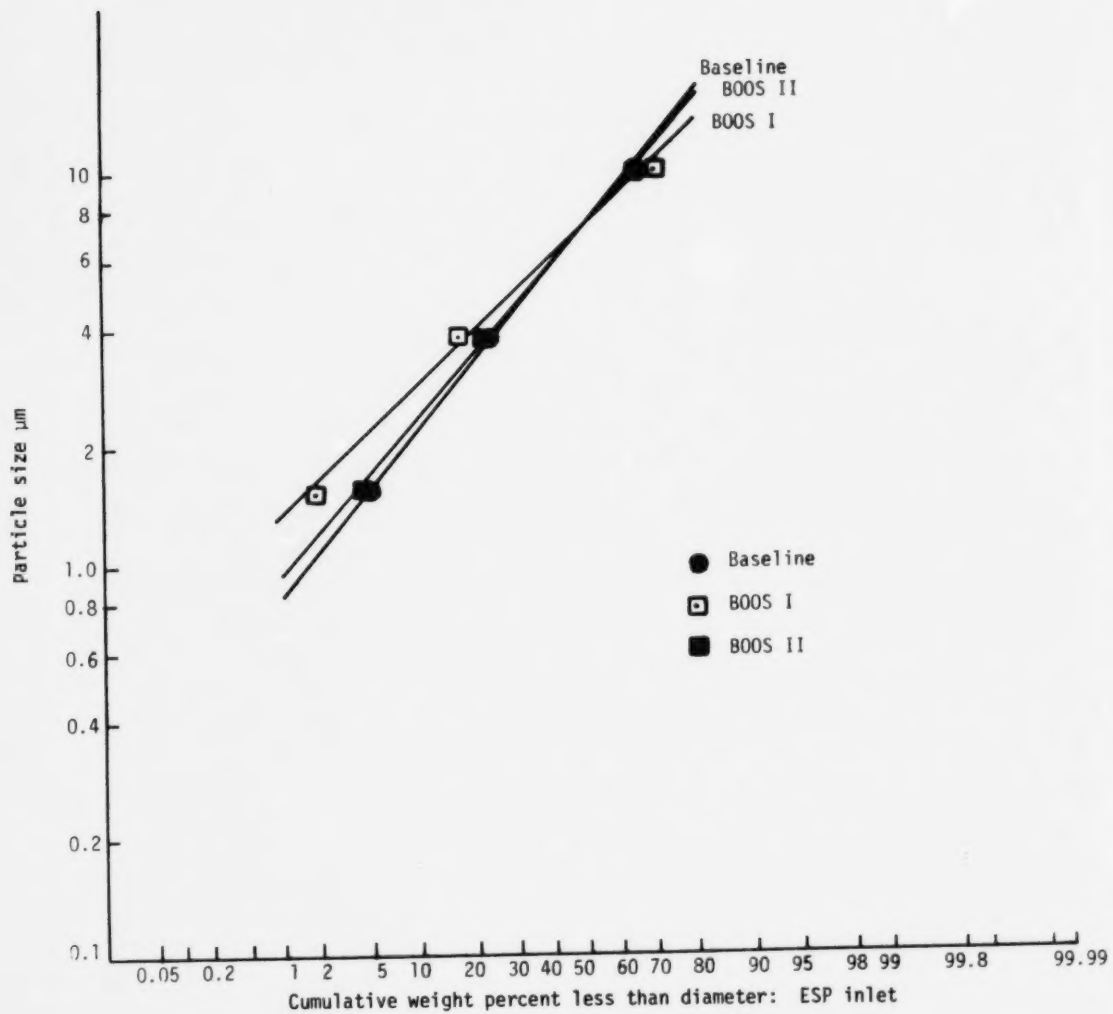


Figure 4-2. Particulate size distribution at the ESP inlet.

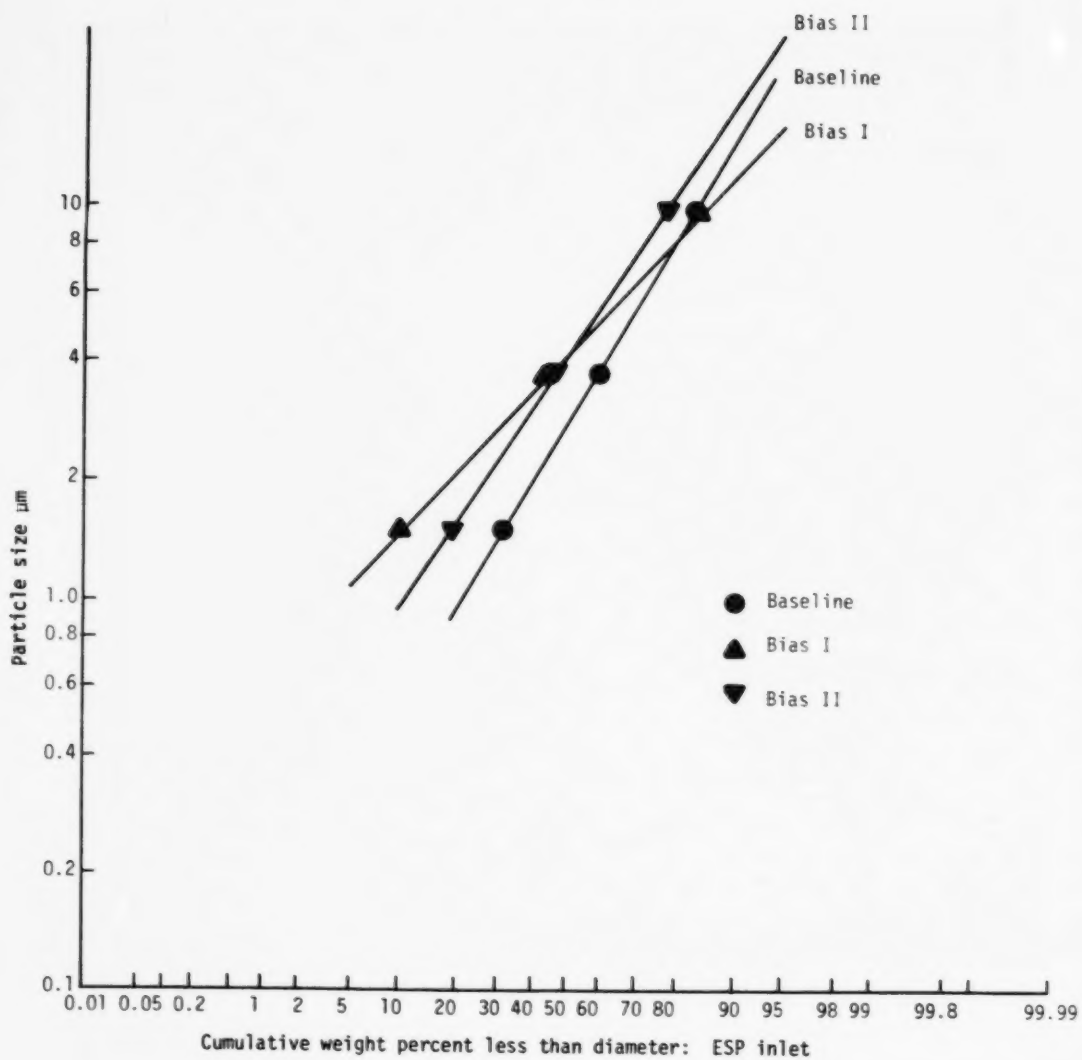


Figure 4-3. Particulate size distribution at the ESP outlet.

TABLE 4-9. PARTICLE SIZE DISTRIBUTION (MICRONS)

Test Sample	Mean Diameter	20% Oversize	80% Oversize
Baseline			
ESP Inlet	7.2	10.6	3.8
ESP Outlet	2.8	8.2	1.0
BOOS I			
ESP Inlet	7.2	10.3	3.9
ESP Outlet	--	--	--
BOOS II			
ESP Inlet	7.2	10.5	3.4
ESP Outlet	--	--	--
Bias I			
ESP Inlet	--	--	--
ESP Outlet	4.2	8.2	2.1
Bias II			
ESP Inlet	--	--	--
ESP Outlet	4.2	10.1	1.6

Trace element concentrations reported for bottom ash, XAD-2, and impingers have been corrected for blank concentrations. The probe wash, 10 m, and 3 m SASS samples were combined into one sample and a single trace element analysis performed. Similarly, the 1 m and filter samples were combined into a single sample of analysis.

Once the trace element concentrations were determined, trace element flowrates for each of the streams sampled could be computed. To calculate flows of the bottom ash and mechanical hopper ash trace elements, an 80/20 flyash to bottom ash split was assumed. This means that 20 percent of the ash in the coal became bottom ash while the remainder left the boiler, suspended in the flue gas. This assumed ash split is reasonable for the Kingston firing configuration (Reference 7)

and was verified by TVA personnel. Trace element flows in the bottom ash and mechanical collector ash are thus approximations. The trace element flowrates are presented in Appendix D.

In previous studies attempting to characterize trace element flows through coal-fired power plants, trace element partitioning has been observed. That is, it has been found that the concentrations of certain materials are higher in certain ash streams. It has also been noted that there is a tendency for particular trace elements to concentrate in particulate as a function of particle size. Size partitioning and stream partitioning are quite closely related. The separation between bottom ash and flyash is dependent on particle size and behavior at furnace temperatures. Some trace elements show selective concentration according to particle size. The collection efficiencies of the various particulate removal devices are largely size dependent. Thus size partitioning has a strong influence on stream partitioning. Among the elements found to concentrate in the smaller particle sizes in previous studies are: antimony, arsenic, cadmium, chromium, lead, nickel, selenium, thallium, and zinc. Limited concentration tendencies have been observed for beryllium, and vanadium (Reference 7).

With respect to stream partitioning, the majority of trace elements (relevant to this study) have been put into one of three groups (Reference 7):

- Group I -- Partitioned about equally between the inlet flyash and bottom ash
- Group II -- Preferentially concentrated in the flyash
- Group III -- Remain largely in the gas phase

A tabulation of the trace elements analyzed in these tests and their group assignment from Reference 7 are given in Table 4-10.

Table 4-11 lists the volatility indices for various trace elements as reported in Reference 7. The more volatile of this group can be expected to reside almost entirely in the gas phase at the elevated temperatures found in the boiler exhaust system.

Solid Phase Trace Element Concentrations

Trace element concentrations (Appendix C) in the bottom ash were compared to those in the mechanical collector hopper to determine if solid phase trace element stream partitioning could be observed. As a result of this comparison, the trace elements were put into three groupings depending on whether: the material was partitioned about equally between bottom ash and flyash (EQ); the material was preferentially concentrated in the flyash (FA) or; the material was concentrated in the bottom ash (BA).

The following criteria were used for categorizing:

- If the concentration of a particular element did not differ by a factor of two or greater, when comparing flyash concentrations to bottom ash concentrations, the element was said to partition equally (EQ)
- If the concentration of a given element in one stream was two or more times greater than its concentration in the other stream, it was judged to partition in the former stream.

As shown in Table 4-12, almost all of the trace elements had concentrations which were enhanced in the flyash or partitioned equally between the bottom ash and flyash streams. With the exception of copper, the partitioning tendencies found in this study would be expected from the information found in Table 4-10.

TABLE 4-10. TRACE ELEMENT STREAM PARTITIONING^a
(Reference 7)

Group I	Group II	Group III	Intermediate I-II
Barium	Antimony	Chlorine	Chromium
Cobalt	Arsenic	Fluorine	Nickel
Iron	Cadmium	Mercury	Uranium
Manganese	Copper	Thallium	Vanadium
Titanium	Lead		
	Molybdenum		
	Selenium		
	Zinc		

^aThe elements: Beryllium, Bismuth, Boron, Tellurium, and Zirconium were not placed in a group.

TABLE 4-11. VOLATILITY OF TRACE ELEMENTS IN COAL
(Reference 7)

Temperature Ranges for Trace Element Volatilization				
1	2	3	4	5
300°F	300-850°F	850-1300°F		>1300°F
Antimony	Arsenic	Barium ^a	Cadmium ^c	Beryllium
Fluorine	Chlorine	Zinc ^a	Chromium ^b	Boron
Mercury	Selenium		Copper	Titanium
Thallium	Tellurium		Cobalt	
			Lead	
			Manganese	
			Nickel ^b	
			Tin	
			Vanadium	

^aPreferentially concentrated in fine particles of flyash
(pulverized firing)

^bConcentrated in crust of moderate-sized particles of flyash
(pulverized firing)

^cLarge percentage to bottom ash (pulverized firing).

TABLE 4-12. SOLIDS TRACE ELEMENT PARTITIONING -- BOTTOM ASH/FLYASH
(Mechanical Collector Hopper Flyash)

	Baseline	BOOS I	BOOS II	Bias I	Bias II
Antimony	X	X	X	X	X
Arsenic	FA	FA	FA	FA	X
Barium	EQ	EQ	FA	EQ	X
Beryllium	EQ	EQ	EQ	EQ	X
Bismuth	X	X	X	X	X
Boron	FA	FA	FA	FA	X
Cadmium	X	X	X	X	X
Chromium	EQ	EQ	EQ	EQ	X
Cobalt	EQ	EQ	EQ	EQ	X
Copper	EQ	EQ	EQ	EQ	X
Iron	EQ	EQ	EQ	EQ	X
Lead	FA	FA	FA	FA	X
Manganese	EQ	EQ	EQ	EQ	X
Mercury	EQ	BA	BA	BA	X
Molybdenum	X	X	X	X	X
Nickel	EQ	EQ	EQ	FA	X
Selenium	X	X	X	X	X
Tellurium	X	X	X	X	X
Thallium	X	X	X	X	X
Tin	X	EQ	X	X	X
Titanium	EQ	EQ	EQ	EQ	X
Uranium	EQ	X	X	X	X
Vanadium	EQ	EQ	EQ	EQ	X
Zinc	FA	FA	FA	EQ	X
Zirconium	BA	BA	BA	BA	X
Chloride	EQ	EQ	EQ	EQ	X
Fluoride	FA	EQ	BA	BA	X
Cyanide	X	X	X	X	X
Nitrate	X	BA	X	X	X
Sulfate	FA	FA	FA	EQ	X
Ammonium	X	FA	FA	FA	X

EQ - Material partitioned equally between bottom ash and flyash
 FA - Material preferentially concentrated in mechanical collector
 hopper flyash
 BA - Material preferentially concentrated in bottom ash
 X - Insufficient data.

Beryllium, boron, and zirconium were not classified in Table 4-10. Our results show beryllium concentrating equally in the bottom ash and flyash, boron concentrating in the flyash, and zirconium concentrating in the bottom ash.

Low NO_x firing implementation shows little effect on trace element partitioning between bottom ash and flyash based on the categorization criteria used. The data show that mercury and fluorine became more concentrated in the bottom ash with low NO_x firing.

Further flyash stream partitioning can be examined by comparing trace element concentrations in the particulate in the direction of flue gas flow. As the particulate laden flue gas passes through particulate removal devices, trace element stream partitioning may be observed. Particulate collection efficiencies are largely particle size dependent, with the coarser particulate more easily removed. Thus flyash stream partitioning is actually size partitioning.

Trace element concentrations in the mechanical collector hopper flyash and the ESP inlet flyash (Appendix C) were compared. Using the same categorizing criteria as in the bottom ash/flyash comparison, trace element concentration data were evaluated for partitioning. Results of this comparison are listed in Table 4-13. Trace species concentrating in the ESP inlet flyash were: arsenic, lead, mercury, tellurium, zinc, zirconium, fluoride, and sulfate. Trace elements found equally partitioned were: beryllium, chromium, cobalt, copper, iron, manganese, titanium, and vanadium. The remaining species either showed varying preferential concentration or the data were insufficient to make any comparison. Low NO_x firing does not appear to affect the partitioning

TABLE 4-13. TRACE ELEMENT PARTITIONING -- MECHANICAL COLLECTOR
HOPPER FLYASH/ESP INLET FLYASH

	Baseline	BOOS I	BOOS II	Bias I	Bias II
Antimony	X	X	X	X	X
Arsenic	FA ₂	FA ₂	FA ₂	FA ₂	X
Barium	EQ	FA ₁	FA ₂	EQ	X
Beryllium	EQ	EQ	EQ	EQ	X
Bismuth	X	X	X	X	X
Boron	X	X	X	X	X
Cadmium	X	X	X	X	X
Chromium	EQ	EQ	EQ	EQ	X
Cobalt	EQ	EQ	EQ	EQ	X
Copper	EQ	EQ	EQ	EQ	X
Iron	EQ	EQ	EQ	EQ	X
Lead	FA ₂	FA ₂	FA ₂	FA ₂	X
Manganese	EQ	EQ	EQ	X	X
Mercury	FA ₂	FA ₂	FA ₂	FA ₂	X
Molybdenum	X	X	X	X	X
Nickel	EQ	EQ	FA ₂	FA ₂	X
Selenium	X	X	X	X	X
Tellurium	FA ₂	FA ₂	FA ₂	FA ₂	X
Thallium	X	X	X	X	X
Tin	FA ₂	X	X	X	X
Titanium	EQ	EQ	EQ	EQ	X
Uranium	X	X	X	X	X
Vanadium	EQ	EQ	EQ	EQ	X
Zinc	FA ₂	FA ₂	FA ₂	FA ₂	X
Zirconium	FA ₂	FA ₂	FA ₂	EQ	X
Chloride	EQ	EQ	FA ₂	EQ	X
Fluoride	EQ	FA ₂	FA ₂	FA ₂	X
Cyanide	X	X	X	X	X
Nitrate	X	X	X	X	X
Sulfate	FA ₂	FA ₂	FA ₂	FA ₂	X
Ammonium	X	FA ₁	FA ₂	FA ₁	X

EQ - Material partitioned equally between mechanical collector hopper flyash and ESP inlet flyash

FA₁- Material preferentially concentrated in mechanical collector hopper flyash

FA₂- Material preferentially concentrated in ESP inlet flyash

X - Insufficient data.

of trace species between the mechanical collector hopper and the inlet to the ESP.

A similar comparison was made between the elemental concentrations in the flyash in the ESP hopper and in the ESP flue gas exit streams. The results are given in Table 4-14.

Of the 22 species examined, 12 were found to concentrate about equally in the ESP hopper and the ESP flue gas outlet. These were arsenic, barium, beryllium, chromium, cobalt, iron, lead, manganese, titanium, vanadium, zinc, and sulfate. The four found with relatively higher concentrations in the flyash outlet were: zirconium, chloride, fluoride, and nitrate. Variable partitioning tendencies were found in the cases of copper, mercury, nickel, selenium, and ammonium. Low NO_x firing does not appear to have any significant effect on trace element partitioning patterns in the ESP.

Size Fractionation

Sampling at both the inlet and outlet of the ESP was conducted using a SASS train as mentioned previously. For the majority of tests, SASS trains were equipped with 10, 3, and 1 micron cyclones followed by a filter. Trace element analyses were conducted on combined 10 μm and 3 μm samples, and 1 μm and filter samples. A tabulation of the analytical results are shown in Appendix C.

These data were examined to determine if selective trace element partitioning occurs with particle size. Table 4-15 illustrates the presence of this effect at the ESP inlet. Those species whose concentrations were higher in small particles for a majority of the tests were antimony, lead, zinc, zirconium, chloride, and sulfate. Low NO_x

TABLE 4-14. TRACE ELEMENT PARTITIONING -- ESP
HOPPER FLYASH/ESP OUTLET FLYASH

	Baseline	BOOS I	BOOS II	Bias I	Bias II
Antimony	X	FA ₄	X	X	X
Arsenic	EQ	EQ	EQ	EQ	X
Barium	EQ	EQ	FA ₄	EQ	X
Beryllium	EQ	EQ	EQ	EQ	X
Bismuth	X	X	X	X	X
Boron	X	X	X	X	X
Cadmium	X	X	X	X	X
Chromium	EQ	EQ	EQ	EQ	X
Cobalt	EQ	EQ	EQ	EQ	X
Copper	EQ	FA ₄	EQ	EQ	X
Iron	EQ	EQ	EQ	EQ	X
Lead	EQ	FA ₄	EQ	EQ	X
Manganese	EQ	EQ	EQ	EQ	X
Mercury	FA ₄	EQ	EQ	EQ	X
Molybdenum	EQ	X	X	X	X
Nickel	FA ₄	EQ	FA ₄	EQ	X
Selenium	EQ	FA ₄	FA ₄	EQ	X
Tellurium	X	FA ₄	X	X	X
Thallium	X	X	X	X	X
Tin	X	X	X	X	X
Titanium	EQ	EQ	EQ	EQ	X
Uranium	EQ	EQ	X	FA ₄	X
Vanadium	EQ	EQ	EQ	EQ	X
Zinc	EQ	EQ	EQ	EQ	X
Zirconium	FA ₄	FA ₄	FA ₄	FA ₄	X
Chloride	FA ₄	FA ₄	FA ₄	FA ₄	X
Fluoride	FA ₄	FA ₄	FA ₄	FA ₄	X
Cyanide	X	X	X	X	X
Nitrate	X	FA ₄	FA ₄	FA ₄	X
Sulfate	EQ	EQ	EQ	EQ	X
Ammonium	FA ₃	FA ₄	FA ₄	FA ₄	X

EQ - Material partitioned about equally between ESP outlet and
ESP hopper flyash

FA₃- Material preferentially concentrated in ESP hopper flyash

FA₄- Material preferentially concentrated in ESP exit stream flyash

X - Insufficient data.

TABLE 4-15. SIZE FRACTIONATION -- ESP INLET

	Baseline	BOOS I	BOOS II	Bias I	Bias II
Antimony	2	2	2	2	2
Arsenic	2	2	0	0	0
Barium	0	0	1	0	0
Beryllium	0	0	0	0	0
Bismuth	X	X	X	X	X
Boron	X	X	X	X	X
Cadmium	X	X	X	X	X
Chromium	0	0	0	0	0
Cobalt	0	0	0	0	0
Copper	0	0	0	0	0
Iron	0	0	0	0	0
Lead	2	2	2	0	0
Manganese	0	0	0	0	0
Mercury	0	2	0	0	1
Molybdenum	X	X	X	X	X
Nickel	0	0	0	0	0
Selenium	X	X	X	X	X
Tellurium	2	2	1	1	1
Thallium	X	X	X	X	X
Tin	0	X	X	X	1
Titanium	0	0	0	0	0
Uranium	X	X	X	X	0
Vanadium	0	0	0	0	0
Zinc	2	2	2	0	0
Zirconium	0	2	1	2	2
Chloride	2	2	2	0	1
Fluoride	0	2	2	0	0
Cyanide	X	X	X	X	X
Nitrate	X	X	X	X	2
Sulfate	0	2	2	2	0
Ammonium	X	X	X	2	2

0 - No significant separation

1 - Concentration enhancement in 10+3 μm fractions

2 - Concentration enhancement in the 1 μm + filter fractions

X - Insufficient data.

firing seemed to have little effect on the tendency to partition with particle size.

Due to lack of data, very little can be said about the tendency of trace elements to segregate with particle size at the outlet of the ESP. Limited analyses indicate lead and ammonium concentrating in finer size particulates while zirconium appeared to concentrate in the coarser fractions (Appendix C).

Vapor Phase Trace Element Concentrations

Vapor phase trace element concentrations were obtained from the SASS train samples. The vapor phase species were collected in either the organics module or the impinger portions of the SASS train. In the organics module, flue gas is cooled to approximately 20°C (68°F) and passed through a cross linked porous polymer resin (XAD-2) cartridge. In this section, two samples are generated: the condensate and the XAD-2 sorbent. From the organics module, the flue gas goes through an impinger train with hydrogen peroxide and silver nitrate ammonium persulfate solutions. For trace element analysis, the organic module aqueous condensate sample is combined with the hydrogen peroxide impinger sample for one sample of analysis. Thus three vapor phase samples are analyzed: the XAD-2, the aqueous condensate and hydrogen peroxide impinger solution, and the silver nitrate ammonium persulfate impinger solution.

To determine which trace elements were more concentrated in the vapor phase than in the condensed phase, trace element flowrates (Appendix D) were compared. Using the same stream partitioning criteria as before, trace elements were considered to be concentrated in the vapor phase if their vapor phase concentrations were at least twice their solid phase concentrations. The partitioning results are given in Table 4-16.

TABLE 4-16. TRACE ELEMENT PARTITIONING -- SOLID PHASE/VAPOR PHASE

	Baseline		B00S I		B00S II		Bias I		Bias II	
	ESP Inlet	ESP Outleta	ESP Inlet	ESP Outlet	ESP Inlet	ESP Outleta	ESP Inlet	ESP Outlet	ESP Inlet	ESP Outlet
Antimony	X	S	X	S	X	X	X	X	X	S
Arsenic	S	S	S	S	S	S	S	S	S	S
Barium	S	S	S	S	S	S	S	S	S	S
Beryllium	S	X	S	X	S	X	S	S	S	S
Bismuth	X	X	X	X	X	X	X	X	X	X
Boron	X	X	X	X	X	X	X	X	X	X
Cadmium	X	X	X	X	X	X	X	X	X	X
Chromium	V	V	V	V	V	V	V	V	V	V
Cobalt	S	X	S	EQ	S	EQ	S	EQ	S	EQ
Copper	EQ	EQ	S	S	EQ	EQ	S	EQ	EQ	EQ
Iron	S	S	S	S	S	S	S	S	S	S
Lead	S	X	S	S	S	X	S	S	S	S
Manganese	S	EQ	S	EQ	S	EQ	S	EQ	S	EQ
Mercury	V	V	V	V	V	V	V	V	V	V
Molybdenum	X	X	X	X	X	X	X	X	X	X
Nickel	V	V	V	V	V	V	V	V	V	V
Selenium	X	V	X	V	X	S	X	X	X	S
Tellurium	S	S	S	X	S	X	S	X	S	S
Thallium	S	S	S	X	S	X	S	X	S	S
Tin	S	S	S	X	S	X	S	X	S	S
Titanium	S	S	S	X	S	X	S	X	S	S
Uranium	S	S	S	X	S	X	S	X	S	S
Vanadium	S	S	S	X	S	X	S	X	S	S
Zinc	EQ	EQ	S	EQ	S	EQ	S	EQ	S	EQ
Zirconium	S	EQ	S	S	S	X	S	S	S	S

aIncludes XAD-2 concentration

EQ - Material partitioned equally between vapor and solid phase
S - Material preferentially concentrated in solid phase
V - Material preferentially concentrated in vapor phase
X - Insufficient data

As noted in Table 4-16, XAD-2 samples were analyzed from only two SASS trains. The contributions to the vapor phase concentrations from the XAD-2 samples were, however, minimal.

The partitioning between vapor and solid phases is not strongly affected by low NO_x firing. Chromium, mercury, and nickel showed high vapor phase concentrations. The chromium and nickel values are suspect, however. The aqueous condensate sample is collected in a stainless steel cup in the SASS train organics module. Since the condensate is acidic, chromium and nickel from the stainless steel are likely to appear in the sample. This is probably true for iron also. Due to the high concentration of iron in the particulate samples, though, the presence in the vapor phase samples was small by comparison.

Effects Due to NO_x Controls

In general, the changes in trace specie emissions due to NO_x control implementation were within the accuracy of the analysis. Notable exceptions are increased leachable nitrate and ammonium compounds. Table 4-17 lists the flue gas trace element concentrations at the ESP outlet for the Baseline, Bias I, and BOOS II tests. The emissions include both vapor phase and solid phase trace elements with the exception of the Bias I XAD-2 sample contribution.

Elemental Mass Balance

A system species mass balance was performed using trace element flow data (Appendix D). In the majority of cases these calculations do not include elemental catches in the XAD-2 samples. Most of the XAD-2 laboratory analyses did not produce concentrations greater than the XAD-2 blank sample analysis.

TABLE 4-17. FLUE GAS TRACE ELEMENT CONCENTRATIONS AT ESP OUTLET

Test	Baseline	Bias I	BOOS II
Heat Input (% of baseline)	100	100.9	92.4
Emissions $\frac{g}{M^3}$ dry			
NO _x (ppm @ 3% O ₂ dry)	1.16x10 ⁶ (490)	7.35x10 ⁵ (336)	6.54x10 ⁵ (304)
*SO ₂ (ppm @ 3% O ₂ dry)	4.18x10 ⁶ (1668)	3.5x10 ⁶ (1354)	4.21x10 ⁶ (1591)
SO ₃ (ppm @ 3% O ₂ dry)	1.20x10 ⁴ (3)	1.10x10 ⁴ (3)	1.20x10 ⁴ (3)
CO (ppm @ 3% O ₂ dry)	3.07x10 ⁴ (28.6)	4.58x10 ⁴ (35.0)	3.19x10 ⁴ (21.7)
CO ₂ (%)	2.72x10 ⁸ (13.9)	2.82x10 ⁸ (14.4)	2.86x10 ⁸ (14.6)
O ₂ (%)	(5.2)	(4.7)	(4.4)
Particulate	6.3x10 ⁵	6.7x10 ⁵	4.3x10 ⁵
Antimony	3.9	<2.7	<2.6
Arsenic	95	78	81
Barium	2.25x10 ³	1.7x10 ³	1.5x10 ³
Beryllium	9.0	11	7.2
Bismuth	<53	<56	2.3x10 ²
Boron	--	--	8.8x10 ²
Cadmium	<2.3	<2.4	<2.1
Chromium	1.69x10 ³	4.7x10 ²	2.4x10 ³
Cobalt	66	75	89
Copper	2.9x10 ²	3.3x10 ²	3.2x10 ²
Iron	4.5x10 ⁴	3.3x10 ⁴	3.3x10 ⁴
Lead	74	86	61
Manganese	2.4x10 ²	1.3x10 ²	1.9x10 ²
Mercury	1.8	0.06	3.5
Molybdenum	1.5x10 ²	<56	8.7x10 ²
Nickel	8.0x10 ²	2.6x10 ²	1.5x10 ³
Selenium	9.9	3.0	<5.1
Tellurium	<4.1	<4.0	<3.7

*By EPA Method 8

TABLE 4-17. Concluded

Test	Baseline	Bias I	BOOS II
Thallium	<2.6	<2.7	<2.1
Tin	<6.4	<6.7	<5.1
Titanium	6.1×10^3	5.7×10^3	3.6×10^3
Uranium	<3.9	7.5	<2.1
Vanadium	2.6×10^2	2.3×10^2	1.6×10^2
Zinc	4.2×10^2	4.3×10^2	2.0×10^2
Zirconium	2.7×10^2	2.6×10^2	6.8×10^2
Chloride	2.7×10^2	4.1×10^2	8.5×10^2
Fluoride	84	3.5×10^2	1.2×10^2
Cyanide	<1.3	<0.3	<1.3
Nitrate	<3.9	<26	7.7×10^2
Sulfate	2.4×10^4	1.2×10^4	2.9×10^4
Ammonium	<5.3	7.2	1.4×10^2
Coal Analysis % by Wt.			
C	63.13	63.46	64.00
H	4.27	4.24	4.23
O	7.34	7.97	7.11
N	1.38	1.13	1.38
S	2.19	1.75	2.13
H ₂ O	2.04	2.34	2.58
Ash	19.60	19.09	18.49
HHV Btu/lb	11302	11334	11402

Bottom ash and mechanical hopper ash flows were estimated. The bottom ash/flyash ratio was assumed to be 20/80, independent of the firing condition. Therefore, it would be possible to change the overall mass balance of a species by assuming a different bottom ash/flyash split.

Table 4-18 presents the results of the system mass balance. Since all the balances are generally greater than 100 percent, it is possible in about half the cases to force the balance closer to 100 percent by assuming a larger bottom ash/flyash ratio. Considering these factors affecting the mass balance, the data are within the reliability of the Level 1 sampling and analysis procedures, which as noted previously, are assumed to be quantitative within a factor of 2 to 3.

4.5 SULFUR SPECIES EMISSIONS

Sulfur species were analyzed in all sample streams according to the following protocol:

- Coal -- sulfur by ultimate analysis
- Bottom ash -- sulfate by turbidimetric method
- Flue gas at air heater flue gas inlet -- SO_2 by continuous monitor (nondispersive ultraviolet absorption)
- Mechanical collector ash -- sulfate by turbidimetric method
- Flue gas at ESP inlet -- SO_2 and SO_3 by EPA Method 8 and sulfate on particulate by turbidimetric method
- ESP ash -- sulfate by turbidimetric method
- Flue gas at ESP outlet -- SO_2 and SO_3 by EPA Method 8 and sulfate on particulate by turbidimetric method

Assuming a 20/80 bottom ash to flyash ratio, a sulfur balance could thus be performed considering all sample streams.

TABLE 4-18. TRACE ELEMENT MASS BALANCE -- (OUTLET/INLET)^a

	Baseline	BOOS I	BOOS II	Bias I
Antimony	X	X	X	X
Arsenic	2.71	5.63	1.73	8.00
Barium	4.67	17.9	3.32	8.57
Beryllium	1.46	3.01	2.20	2.31
Bismuth	X	X	X	X
Boron	X	X	X	X
Cadmium	X	X	X	X
Chromium	1.30	3.47	0.922	3.54
Cobalt	1.53	2.96	0.66	1.74
Copper	1.01	1.17	1.27	1.11
Iron	2.40	1.12	1.32	1.10
Lead	X	X	X	X
Manganese	2.47	1.01	0.73	X
Mercury	0.437	1.23	0.491	0.059
Molybdenum	X	X	X	X
Nickel	1.61	1.30	0.39	0.947
Selenium	X	X	X	X
Tellurium	X	X	X	X
Thallium	X	X	X	X
Tin	X	X	X	X
Titanium	2.90	1.67	1.73	1.46
Uranium	X	X	X	X
Vanadium	1.30	0.946	0.894	0.852
Zinc	0.97	1.26	1.33	0.910
Zirconium	X	X	X	0.124

X -- Insufficient data

^aLess than detection limit taken as zero

The results of the sulfur species analyses are presented in Table 4-19. The data show that the SO_2/SO_3 ratio is not strongly affected by the changes in firing modes. The data also show that levels of sulfate in the ash samples are higher in the smaller size particulates, regardless of firing mode. This is seen in the progressively higher sulfate levels in the direction of flue gas flow and also in the comparison of different size particulate samples collected by the SASS train. In comparing the sulfate analyses of the SASS and Method 8 samples, it should be noted that the Method 8 data includes any condensed material in the sampling probe wash while the SASS data accounts only for sulfate in the particulate.

The results of the sulfur balance data in Table 4-20 show that with the exception of the BOOS I test, mass balance closure of greater than 90 percent is consistently achieved when all samples have been analyzed. There are some inconsistencies in the data. The coal sulfur analysis in the BOOS I test is not consistent with the coal sulfur and SO_2 continuous monitor data from the other tests. Also, the EPA Method 8 results for SO_2 for the BOOS I test are inconsistent. However, the results from the remaining tests agree very well.

4.6 ORGANIC ANALYSES

Organic analyses were performed on selected samples according to the EPA Level 1 protocol as outlined in Appendix B (References 2 and 4). The organic analyses were performed by the Foremost Foods Company, Research and Development Center. Excerpts from their report are given in this section, and in Appendix B.

The samples were analyzed as follows: First they were extracted with methylene chloride in a Soxhlet apparatus. The extracts were then

TABLE 4-19. SULFUR SPECIES ANALYSES RESULTS

Test	Baseline	800S I	800S II	Bias I	Bias II
Heat Input MW	227.1	206.4	209.8	229.2	227.3
Coal - Sulfur % (ng/J)	2.19 (834)	2.40 (895)	2.13 (804)	1.75 (664)	1.75 (615)
Bottom Ash Sulfate $\mu\text{g/g}$ (ng/J)	500 (0.746)	<0.1 ($<1.4 \times 10^{-4}$)	400 (0.558)	530 (0.768)	-- --
Flue Gas - Cont. Monitor SO ₂ g/dscm (ng/J) (ppm dry @ 3% O ₂)	5.2 (1831) (2059)	5.1 (2057) (1893)	4.9 (1859) (1865)	4.0 (1400) (1527)	4.3 (1330) (1612)
Mechanical Collector Ash Sulfate $\mu\text{g/g}$ (ng/J)	1700 (7.75)	730 (3.77)	1300 (5.65)	1000 (4.42)	-- --
<u>ESP Inlet - Method 8</u>					
Particulate - Sulfate $\mu\text{g/g}$ (ng/J)	7800 (11.0)	6250 (4.0)	3000 (3.9)	4500 (5.6)	10800 (5.5)
SO ₂ g/dscm (ng/J)	4.4 (1550)	5.8 (2340)	3.9 (1480)	3.4 (1190)	3.2 (990)
SO ₃ mg/dscm (ng/J)	16 (5.6)	23 (9.3)	10 (3.8)	10 (3.5)	8 (2.4)
<u>ESP Inlet - SASS</u>					
10 μ + 3 μ - Sulfate $\mu\text{g/g}$ (ng/J)	4100 (4.44)	3000 (1.44)	3800 (3.62)	1900 (2.48)	2600 (1.35)
1 μ + Filter - Sulfate $\mu\text{g/g}$ (ng/J)	7300 (2.34)	8800 (0.87)	9200 (2.55)	8400 (0.57)	4500 (0.14)
ESP Hopper Ash - Sulfate $\mu\text{g/g}$ (ng/J)	5200 (6.02)	5100 (1.65)	4400 (4.71)	4600 (5.41)	-- --

TABLE 4-19. (Concluded)

Test	Baseline	B00S I	B00S II	Bias I	Bias II
<u>ESP Outlet - Method 8</u>					
Particulate - Sulfate $\mu\text{g/g}$ (ng/J)	37800 (8.6)	32200 (8.5)	60500 (11.0)	18200 (4.4)	39200 (5.2)
SO ₂ g/dscm (ng/J)	4.2 (1500)	1.6 (660)	4.2 (1570)	3.5 (1250)	3.1 (1000)
SO ₃ mg/dscm (ng/J)	12.0 (4.3)	16.0 (6.6)	12.0 (4.5)	11.0 (3.9)	7.9 (2.6)
<u>ESP Outlet - SASS</u>					
10 μ + 3 μ - Sulfate $\mu\text{g/g}$ (ng/J)	7800 (0.72)	-- --	-- --	5300 (0.72)	9100 (0.79)
1 μ + filter - sulfate $\mu\text{g/g}$ (ng/J)	12000 (1.62)	4000 (1.06)	4900 (0.78)	6400 (0.66)	16000 (1.09)

TABLE 4-20. SULFUR BALANCE

Test	Baseline	B00S I	B00S II	Bias I	Bias IIa
Sulfur in coal ng/J	834	895	804	664	615
Sulfur in bottom ash ng/J	0.25	0	0.19	0.26	--
Sulfur in mechanical collector ash ng/J	2.6	1.3	1.9	1.5	--
Sulfur as SO ₂ /SO ₃ /SO ₄ at ESP inlet ng/J (EPA Method 8)	781	1175	743	598	498
Recovery at ESP inlet %	93.9	131.4	92.7	90.3	80.9
Sulfur in ESP ash ng/J	2.0	0.55	1.6	1.8	--
Sulfur as SO ₂ /SO ₃ /SO ₄ at ESP outlet ng/J (EPA Method 8)	755	335	790	628	503
Recovery at ESP outlet %	91.1	37.6	98.7	95.1	81.8

^aSulfate determinations on ash were not performed on the BIAS II samples.

subjected to total chromatographable organic (TCO) and gravimetric analyses which determine species with boiling points in the ranges of 100°C to 300°C and greater than 300°C respectively. Infrared spectra were also performed. If certain TCO and gravimetric requirements were met, further analyses by liquid column chromatography, with infrared and mass spectral analyses of the fractions eluted from the column, were performed. In addition flue gas C₁ to C₆ hydrocarbon compounds were analyzed onsite by gas chromatography. Oxygen demand tests were performed (biological and chemical oxygen demand) on bottom ash sluice samples. The analysis schedule is given in Table 3-2. A full set of analyses were performed on the Baseline and BOOS II tests. More limited analyses were performed on the remaining tests. A discussion of the analytical results follows.

4.6.1 Total Chromatographable Organics (TCO) and Gravimetric Analyses of Organic Extracts

Total chromatographable organics (TCO) and gravimetric analyses were performed on organic extracts of the samples from the Baseline and BOOS II tests. The samples analyzed were the bottom ash solids, mechanical collector hopper ash, electrostatic precipitator hopper ash, the particulate samples collected by the SASS trains at both the inlet and outlet of the ESP, and the XAD-2 sorbent samples collected by the SASS train at the ESP outlet.

Detailed analysis results are presented in Table 4-21. Table 4-22 illustrates the degree of precision of the analysis. The results of the analyses indicate that the range of concentrations of organic materials (TCO plus gravimetric) in bottom ash, mechanical collector hopper ash, and ESP hopper ash is 1 to 7 µg/gm. The low NO_x, BOOS II, test generally

TABLE 4-21(a). RESULTS OF GRAVIMETRIC AND TCO ANALYSES OF ASH SAMPLES

Test	Type of Ash	Gravimetric Result (mg)	TCO Result (mg)	Total Organics in Extract (mg)	Wt. of Sample Extracted (g)	Organics in Total Sample $\mu\text{g/g}$
Baseline	Bottom	0.3	<0.1	0.3	202	1.5
B00S II	Bottom	10.8	<0.1	10.8	2600	4.2
Baseline	Mechanical hopper	<0.1	<0.1	0.2	150	1.3
B00S II	Mechanical hopper	2.2	0.3	2.5	790	3.2
Baseline	ESP hopper	0.2	<0.1	0.2	146	1.4
B00S II	ESP hopper	1.0	<0.1	1.0	150	6.7

TABLE 4-21(b). RESULTS OF GRAVIMETRIC AND TCO ANALYSES OF SASS SAMPLES

Test	Sample Type	Gravimetric Result (mg)	TCO Result (mg)	Total Organics in Extract (mg)	Wt. of Sample Extracted (g)	Total Wt. of Sample (g)	Organics in Total Sample		
							(mg)	µg/g	µg/dscm
Baseline	XAD-2, outlet	0.2	<0.1	0.2	167	334	0.4	1.2	19
800S II	XAD-2, outlet	0.8	<0.1	0.8	79.1	158	1.6	10.1	140
Baseline	Condensate, outlet	1.2	<0.1	1.2	Entire sample	Entire sample	1.2	--	56
800S II	Condensate, outlet	7.3	<0.1	7.3	Entire sample	Entire sample	7.3	--	650
Baseline	3µ dust, Inlet 10µ dust, Inlet	1.0	0.24	1.2	20.2 17.8	41.0 37.1	2.4	30.7	130
Baseline	1µ dust Inlet Filter dust, Inlet	0.8	<0.1	0.8	7.4 9.4	14.8 18.8	1.6	47.6	86
800S II	3µ dust, Inlet 10µ dust, Inlet	0.06	<0.1	0.06	20.4 15.6	39.4 32.9	0.1	1.4	4.9
800S II	1µ dust, Inlet Filter dust, Inlet	1.64	<0.1	1.6	1.9 7.7	4.6 16.4	3.2	15.2	160
Baseline	3µ dust, Outlet 10µ dust, Outlet	0.5	<0.1	0.5	1.5 0.8	3.4 1.7	1.0	196.1	47
Baseline	1µ dust, Outlet Filter dust, Outlet	0.02	<0.1	0.02	1.6 1.7	3.2 3.4	0.04	6.1	1.9
800S II	Filter dust, Outlet	0.11	<0.1	0.11	1.5	7.5	0.5	66.7	44
--	Method blank	0.10	<0.1	0.1	--a	--	0.1	--	--

a) 1500 ml of solvent were used.

Volume of gas sampled (dscm)

Baseline	Inlet	18.7	800S II	Inlet	20.5
	Outlet	21.4		Outlet	11.3

TABLE 4-22. REPRODUCIBILITY OF TCO ANALYSES

Sample	TCO Results (mg)
BOOS II Bottom Ash	0.052, 0.039, 0.055
BOOS II Mechanical Collector Hopper Ash	0.203, 0.801
Baseline XAD-2	0.037, 0.053
BOOS II XAD-2	0.067, 0.037

showed higher levels of organic material than the Baseline test. However, replicates of the TCO analyses showed some variability.

The TCO and gravimetric analyses of the SASS train samples suggest several conclusions. In the Baseline test, the organic material is distributed equally between large and small particulate at the ESP inlet, while at the ESP outlet it is concentrated in the large particulate. Because of problems with the SASS train, there was not enough data to make this comparison for the BOOS II test. In both the Baseline and BOOS II tests, particulate organic concentrations were greater at the ESP outlet than at the ESP inlet. But since the dust loading is decreased by the ESP, total emissions of organic material condensed on the particulate are reduced. The levels of the particulate organic emissions are greater for the Baseline test than for the BOOS II test. In contrast, vapor phase organics show a higher concentration in the BOOS II test.

To qualify for liquid column separation, a sample was required to contain at least 15 mg organic material. None of the samples qualified for this procedure. However, the bottom ash sample from the BOOS II test almost met this criterion. This sample was separated for further analysis.

4.6.2 Infrared Spectra of Total Extracts

The materials used in the gravimetric analyses were prepared for infrared spectra determination. Only two of the samples showed significant differences from the method blank. The mechanical hopper ash from the Baseline test and the ESP hopper ash from the B00S II test had spectra indicating the presence of alcohol and aromatic character. The results of the IR analyses of these total extracts are given in Table 4-23. Analytical procedures are discussed in Appendix B.

TABLE 4-23. SUMMARY OF ABSORBANCES FOUND IN SAMPLES, BUT NOT IN METHOD BLANK

Type	Frequency (cm ⁻¹)	Possible Assignment
Mechanical Hopper Ash	1200 1430 (broad) 894 3200 (broad)	Alcohol C-O stretch Alcohol O-H bend Aromatic C-H bend Alcohol or water O-H stretch
B00S II ESP Ash		Same as above

4.6.3 Column Chromatography

The material from the method blank and the B00S II bottom ash extract were concentrated and fractionated according to Level 1 procedures (References 2 and 4). Gravimetric and total chromatographable organic content for each fraction were then obtained. These data, given in Table 4-24, represent the material present in a 2600 gm sample of bottom ash.

TABLE 4-24. GRAVIMETRIC AND TCO RESULTS FROM COLUMN CHROMATOGRAPHY OF THE B00S II BOTTOM ASH

Fraction	Gravimetric Result Method Blank (mg)	TCO Result Method Blank (mg)	Gravimetric Result B00S II Bottom Ash (mg)	TCO Results B00S II Bottom Ash (mg)	Total Organics B00S II Bottom Ash (µg/g)
1	0.48	< 0.1	2.27	< 0.1	0.69
2	0.05	< 0.1	1.15	< 0.1	0.42
3	0.33	< 0.1	0.95	< 0.1	0.24
4	0.65	< 0.1	0.73	< 0.1	0.03
5	0.05	< 0.1	0.83	< 0.1	0.30
6	0.68	< 0.1	5.38	< 0.1	1.81
7	0.88	< 0.1	2.12	< 0.1	0.48
Total	3.12		13.43		3.97

4.6.4 Infrared and Mass Spectral (LRMS and GC/MS) Analyses of Fractions from Column Chromatography

The samples obtained from the column chromatography fractionation of the method blank and B00S II bottom ash extract were split and subjected to infrared and low resolution mass spectral analyses following Level 1 procedures (References 2 and 4). The results of the analyses are given in Tables 4-25 through 4-31. Summary results are presented in Table 4-32. In addition, fractions 2 and 3 were combined and subjected to analysis by gas chromatograph/mass spectrometer for the identification and quantitation of specific polynuclear aromatic compounds. The results of this analysis are given in Table 4-33.

4.6.5 C₁ to C₆ Flue Gas Hydrocarbon Analysis

Onsite analyses of C₁ to C₆ flue gas hydrocarbons were conducted for the Bias I and II, Baseline, and B00S II tests. The flue gas grab samples were analyzed using a gas chromatograph/flame ionization detector. The results of the analyses showed that C₁ to C₆ hydrocarbons were not present above the method detectability limits in any flue gas sample.

4.6.6 Oxygen Demand

Chemical and biological oxygen demands analyses were performed on unfiltered bottom ash slurry samples. The BOD analyses ranged from 1 to 10 mg/l, and the COD analyses ranged from 500 to 5500 mg/l. The results of these analyses are given in Table 4-34.

4.6.7 Summary of Organic Analyses

The organic emissions from the Baseline and B00S II tests were compared. Organic emissions were higher in the B00S II test in every sample except the SASS train particulate. In the SASS train particulate,

TABLE 4-25. LRMS AND IR REPORT -- FRACTION 1. BOOS II BOTTOM ASH

1) Categories present

Name	Evidence		
	LRMS	IR	Intensity
Alkanes	m/e 57, 71, 85 (C_nH_{2n+1})	2860 cm^{-1} C-H stretch 2940 cm^{-1} C-H stretch 1460 cm^{-1} C-H bend	Major
Alkenes	m/e 55, 69, 83 (C_nH_{2n-1})	1390 cm^{-1} C-H bend	Major
Thioalkanes (?)	m/5 45, 59 ($C_nH_{2n-1}S$)	None	Minor

- 2) Molecular weight range 100 to 800.
 3) No specific compounds or subcategories could be identified.
 4) Comments -- All observed IR peaks were also present in Method blank, but were more intense in sample.

TABLE 4-26. LRMS AND IR REPORT -- FRACTION 2. BOOS II BOTTOM ASH

1) Categories present

Name	Evidence		
	LRMS	IR	Intensity
Elemental sulfur (Sg)	m/e 256, 192, 128, 64 with M+2 isotopes	1640cm ⁻¹ S-S stretch(?)	Major
Alkyl chlorides (?)	m/e 49 and 51 (3:1) C _n H _{2n} Cl m/e 84, 86 and 88 (10:6:1) C _n H _{2n} Cl ₂	2920cm ⁻¹ C-H stretch 2860cm ⁻¹ C-H stretch 1460cm ⁻¹ C-H bend	Minor
Alcohols (?)	m/e 59 (C _n H _{2n} +10)	3450cm ⁻¹ broad	Minor

- 2) Molecular weight range -- at least to 300, no evidence for compounds at higher molecular weight.
 3) Elemental sulfur positively identified by M.S.

TABLE 4-27. LRMS AND IR REPORT -- FRACTION 3. BOOS II BOTTOM ASH

1) Categories present

Name	Evidence		
	LRMS	IR	Intensity
Elemental sulfur	m/e 256, 192, 128, 64	None	Minor
Aromatic	None	805cm ⁻¹ C-H bend	Minor
Alcohols (1° and 2°)	m/e 59 and 45 C _n H _{2n+1} O	1267cm ⁻¹ O-H bend 1100 C-O stretch 1030 C-O stretch	Minor

- 2) Molecular weight range 100 to 700.
3) Elemental sulfur positively identified.

TABLE 4-28. LRMS AND IR REPORT -- FRACTION 4. BOOS II BOTTOM ASH

1) Categories present

Name	Evidence		
	LRMS	IR	Intensity
Alcohols	See comment	3440cm ⁻¹ O-H stretch 1390cm ⁻¹ O-H bend 1470cm ⁻¹ C-H bend	Major
Alkenes and alkanes		1640cm ⁻¹ C-C stretch 2920cm ⁻¹ C-H stretch 2860cm ⁻¹ C-H stretch	Major

2) Molecular weight range at least to 350

3) Comment -- There were no significant mass spectral peaks in the sample which were not also observed in the method blank.

TABLE 4-29. LRMS AND IR REPORT -- FRACTION 5. BOOS II BOTTOM ASH

1) Categories present

Name	Evidence		
	LRMS	IR	Intensity
Alcohols	See comment	3430cm ⁻¹ O-H stretch 1398cm ⁻¹ O-H bend	Major
Alkenes and alkanes		1640cm ⁻¹ C-C stretch 2920cm ⁻¹ C-H stretch 2880cm ⁻¹ C-H stretch	Major

2) Molecular weight range -- 100 to 700.

3) Comment -- There were no significant mass spectral peaks in the sample which were not also observed in the method blank. Both sample and blank showed large amounts of phthalates.

TABLE 4-30. LRMS AND IR REPORT -- FRACTION 6. BOOS II BOTTOM ASH

1) Categories present

Name	Evidence		
	LRMS	IR	Intensity
Aromatic	m/e 78	755cm ⁻¹ C-H stretch (5 adjacent hydrogens) 825cm ⁻¹ C-H stretch (4 adjacent hydrogens) 880cm ⁻¹ C-H stretch (1 hydrogen atom) 1460cm ⁻¹ C-C stretch	Minor
Carbonyls and/ or carboxylates	m/e 44, m/e 149, m/e 263 (See comment)	1700cm ⁻¹ C=O stretch 1610cm ⁻¹ Carboxylate anion stretch 1380cm ⁻¹ C-H stretch 2910cm ⁻¹ C-H stretch 3420cm ⁻¹ O-H stretch N-H stretch	Major

- 2) Molecular weight range at least to 300.
- 3) The ion at m/e 44 could be a result of the thermal decomposition of nonvolatile carbonyl compounds. The sample exhibited very intense peaks at m/e 149 and 263, which are masses characteristic of phthalates. This indicates that this fraction probably contains the phthalates which were introduced during sample collection and storage and suggests that most of the peaks observed in the infrared spectrum are the result of phthalates rather than compounds originally present in the ash.
- 4) Specific compounds identified: Butyl phthalyl butyl glycolate - m/e 149, 263.

TABLE 4-31. LRMS AND IR REPORT -- FRACTION 7.
BOOS II BOTTOM ASH

1) Categories present

Name	Evidence		
	LRMS	IR	Intensity
Carboxylic acids	m/e 44, (CO ₂ ⁺)	1398cm ⁻¹ carboxylate anion stretch 1640cm ⁻¹ carboxylate anion stretch	Minor
Alcohols and/or amines		3430cm ⁻¹ O-H or N-H stretch	Minor(?) (see comment)
Phenylalkyl or benzoyl	m/e 105 C ₆ H ₅ CN or C ₆ H ₅ N ⁺ C ₆ H ₄ CO	None	Minor

2) Molecular weight range at least to 450

3) Comment -- A large peak at 3430cm⁻¹ was also observed in the corresponding fraction of the method blank.

TABLE 4-32. LEVEL I ORGANIC EXTRACT SUMMARY BOOS II BOTTOM ASH

Fraction	TCO ($\mu\text{g/g}$)	Gravimetric ($\mu\text{g/g}$)	Total Organics ($\mu\text{g/g}$)	Compound Category	LRMS Intensity	Maximum Concentration ($\mu\text{g/g}$)
1	0	0.69	0.69	Alkanes Alkenes Thioalkanes	100 100 10	0.33 0.33 0.03
2	0	0.42	0.42	Elemental sulfur Alkyl chlorides Alcohols	100 10 10	0.35 0.03 0.03
3	0	0.24	0.24	Elemental sulfur Aromatic Alcohols	10 10 10	0.08 0.08 0.08
4	0	0.03	0.03	Alcohols Alkanes and Alkenes	100 100	0.02 0.02
5	0	0.30	0.30	Alcohols Alkanes and Alkenes	100 100	0.15 0.15
6	0	1.81	1.81	Aromatic Carbonyls and/or Carboxylates	10 100	0.16 1.65
7	0	0.48	0.48	Carboxylic acids Alcohols and/or Amines Phenylalkyl or Benzoyl	10 10 10 10	0.16 0.16 0.16 0.16

TABLE 4-33. RESULTS OF QUANTITATION OF POLYNUCLEAR ORGANIC MOLECULES

Compound	Amount in Method Blank (Fractions 2 and 3) (μg)	Amount in B00S II Bottom Asha (Fractions 2 and 3) (μg)
Phenanthrene and anthracene	<1	7.6 ^b
Benzo(a)anthracene	<1	8.4
Benzo(e)pyrene, perylene, and benzo(a)pyrene	<1	13 ^c
Coronene	<10	<10
Fluoranthene	<1	<1
Pyrene	<1	<1
Benzo(g,h,i)perylene	<10	<10
Anthanthrene	<10	<10

^aIn 2600 gm ash

^bQuantitated as phenanthrene

^cQuantitated as benzo(a)pyrene

TABLE 4-34. RESULTS OF BOD AND COD ANALYSES ON BOTTOM ASH SLURRY

Test	BOD (mg/l)	COD (mg/l)
Baseline	10.3	563
BOOS I	1.0	797
BOOS II	9.1	1634
Bias I	1.1	5538
Bias II	2.2	N.R. ^a

^aNot requested.

the levels were comparable between the two tests. In both tests, however, organic emissions were too low to warrant liquid chromatographic separation and further analysis by EPA Level 1 procedures. More quantitative methods are required for samples with these low organic material concentrations.

SECTION 5

SUMMARY

The test program conducted on Unit 6 of TVA's Kingson Steam Plant compared changes in unit operation and multimedia emissions resulting from NO_x control implementation. The results of a baseline or normal operation test were compared to test results from replicate tests at two different levels of NO_x control. These two levels of NO_x control, biased burner firing (Bias) and burners out of service (BOOS) achieved 30 percent and 37 percent reductions in NO_x from the baseline level. Summaries of the effects on boiler operation and emissions are given below.

Operation

The combustion modification NO_x controls employed in this test program did not appear to cause any operating problems during the test program. Steam temperatures were maintained at 538°C (1000°F). No excessive slagging of the furnace was noticed, either through visual observations or through steam attemperation requirements. It must be noted, however, that these tests were of five to six hours each. The long term effects of continuous operation under low NO_x firing modes were not evaluated.

The combustion modifications consisted of reducing the overall excess air level and firing the lower furnace more fuel rich than the upper furnace. In doing this, more operator vigilance is required. If excess air levels are reduced too much, excursions in carbon monoxide

concentrations will result. This would represent poor fuel utilization and could also lead to serious problems if explosive CO concentrations are reached.

The main operating problem experienced with low NO_x firing was reduced load in the burners out of service mode. By not admitting fuel to one elevation of fuel nozzles, a load limiting condition was reached. During the peak load period, Kingston Unit 6 turbine generator output was 200 MW. During the test program, output was limited to 177 MW, the maximum achievable with one elevation of fuel nozzles admitting air only.

Boiler efficiency remained unchanged or improved slightly with NO_x controls. This was due to lowering the excess air levels without increasing the levels of unburned carbon in the ash.

Emissions

Multimedia emissions were examined for changes due to NO_x controls. Gaseous, particulate, trace element, sulfur species, and organic emissions were evaluated. The test program results are discussed briefly in the following paragraphs.

Gaseous NO_x, CO, and SO₂ were measured by continuous monitors during the tests. The NO_x control methods used resulted in 30 to 37 percent reductions in NO_x from baseline levels. CO levels were controlled at levels below 100 ppm throughout the test program. That is, excess air levels were reduced until increases in CO emissions were seen. The excess air level was then increased slightly to provide a comfortable operating margin. Thus, changes in CO levels resulting from NO_x controls could not be addressed. Emitted SO₂ levels varied only with fuel sulfur content.

Particulate testing showed that biased burner firing resulted in slightly larger particle size than either the burners out of service or baseline firing conditions. ESP collection efficiency showed a slight improvement in the BOOS tests.

Trace element and leachable ionic specie tests showed that trace specie partitioning generally followed the results shown in other tests and that changes in partitioning due to NO_x controls were within the accuracy of the analyses. The leachable nitrate and ammonium compounds were notable exceptions, being higher with a progressive control of NO_x .

The results of the sulfur species analyses showed that the SO_2/SO_3 ratio is not strongly affected by the changes in firing modes. Sulfate concentrations were higher in the smaller particulate regardless of firing mode.

The organic emissions from the Baseline and BOOS II tests were compared. Organic emissions levels were higher in the BOOS II test in every sample except the SASS train particulate catch. In the SASS train particulate, the levels were comparable between the two tests. In both tests, however, organic emissions were too low to warrant liquid chromatographic separation and further analysis by EPA Level 1 procedures. More quantitative procedures would be required for samples with low organic material concentrations.

REFERENCES

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6. Blake, D. E., "Source Assessment Sampling System: Design and Development," EPA-600/7-78-018, January 1977.
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APPENDIX A
OPERATING DATA AND EFFICIENCY TEST RESULTS

Date
Test
Time

Coal Scale A Meter Reading (500 Lb)

B
C
D
E
F

Main Steam Pressure (PSIG) Chart

Turbine 1st Stage Pressure (PSIG)

No. 1 Extraction Pressure (PSIG)

Reheat Inlet Pressure (PSIG) Chart

Reheat Outlet Pressure (PSIG)

A-3 Turbine Exhaust Pressure (in Hg) Chart

Condenser Vacuum (in Hg) Barometer

Barometric Pressure (in Hg) Barometer

Reheat Outlet Temp. (°F) Chart

Superheat Outlet Temp. (°F) Chart

HP Steam Temp. Rt. side (°F) Chart
Left side (°F)

Reheat Steam Temp. Rt. side (°F)
Left side (°F)

Pulverizer Coal-Air Temp. A Chart

B
C
D
E
F

Preceding page blank

NOT APPLICABLE FOR SUMMARY

8/30/77 BASELINE 8/27/77 BOOS I 8/31/77 BOOS II 8/28/77 BIAS I 9/1/77 BIAS II

1804	1802	1804	1812
1107	1123	1104	1116
575	575	571	575
356	351	356	355
329	331	329	329
2.0	1.9	2.0	2.0
27.5	27.5	27.6	27.5
29.55	29.6	29.6	29.6
1001	997	999	995
1001	1000	1001	1001
995	998	998	997
993	993	993	994
990	985	989	988
996	991	994	988
188	110	189	190
188	186	189	190
185	184	186	188
186	184	186	178
186	181	184	187
186	182	184	186

Date
Test
Time

AC Megawatts (Gross) MW Meter

Oxygen (O_2) SH Outlet (%) Chart
RH Outlet (%)

Drum Pressure (PSIG) Gage

SH Header Pressure (PSIG) Gage
RH Header Pressure (PSIG)

Boiler Feedwater Pressure at
Motor Operated Valve (PSIG)

Before Valve Gage
After Valve Gage

Reheat Furnace Air Flow (M lb/hr) Chart
Steam Flow (M lb/hr)
Superheater Furnace Air Flow (M lb/hr)
Steam Flow (M lb/hr)

Feedwater Flow (M lb/hr) Chart

Steam Pressure (PSIG) Chart
Feedwater Pressure (PSIG)

Steam Temp. to Reheater ($^{\circ}\text{F}$)(#4) Chart

Steam Temp. #1 Extraction ($^{\circ}\text{F}$)(#5)

Boiler Feedwater Temp. Inlet #3 Heater
($^{\circ}\text{F}$)(#3) Chart

Boiler Feedwater Temp. Inlet #2 Heater
($^{\circ}\text{F}$)(#4)

8/30/77
BASELINE

8/27/77
BOOS I

8/31/77
BOOS II

8/28/77
BIAS I

9/1/77
BIAS II

178

177

178

177

178

INSTRUMENT NOT WORKING
INSTRUMENT NOT WORKING

1865

1851

1863

1856

1862

1824

1809

1825

1821

1825

340

339

340

341

340

2022

1979

2017

2000

2025

1909

1899

1900

1900

1908

1178

1249

1210

1181

1202

1082

1080

1077

1078

1087

982

926

1010

927

935

1127

1145

1131

1142

1140

1293

1295

1300

1290

1231

1828

1815

1833

1825

1827

2125

2092

2126

2103

2135

654

652

652

654

655

752

752

750

752

752

329

329

329

329

329

400

399

399

398

399

Date
Test
Time

Boiler Feedwater Temp.:

Inlet #1 Heater (°F) (#5)
Leaving #1 Heater (°F) (#6)
Boiler Inlet (°F) (#7)

Drain Temp. #1 Heater (°F) (#8)
#2 Heater (°F) (#9)

Drum Level (in. + or - CL) Chart

Air Entering Air Heater A (°F) (#1) Chart

Air Leaving Air Heater A (°F) (#2)
Gas Entering Air Heater A (°F) (#3)
Gas Leaving Air Heater A (°F) (#4)
Air Entering Air Heater B (°F) (#5)
Air Leaving Air Heater B (°F) (#6)
Gas Entering Air Heater B (°F) (#7)
Gas Leaving Air Heater B (°F) (#8)

Air Entering windbox, superheat Furnace (°F) (#9)

Air Entering windbox, reheat Furnace (°F) (#10)
Gas Leaving superheat Furnace (°F) (#11)
Gas Leaving reheat Furnace (°F) (#12)

Pulverizer A Supply Air Pres. (in H₂O) Gage

Pulverizer A Discharge Pres. (in H₂O)
Pulverizer B Supply Air Pres. (in H₂O)
Pulverizer B Discharge Pres. (in H₂O)
Pulverizer C Supply Air Pres. (in H₂O)
Pulverizer C Discharge Pres. (in H₂O)
Pulverizer D Supply Air Pres. (in H₂O)
Pulverizer D Discharge Pres. (in H₂O)
Pulverizer E Supply Air Pres. (in H₂O)
Pulverizer E Discharge Pres. (in H₂O)
Pulverizer F Supply Air Pres. (in H₂O)
Pulverizer F Discharge Pres. (in H₂O)

8/30/77
BASELINE

8/27/77
BOOS I

8/31/77
BOOS II

8/28/77
BIAS I

9/1/77
BIAS II

443
488
473

443
488
444

443
488
480

443
488
449

443
488
486

482
438

481
438

481
438

481
438

481
438

-0.5

-0.5

-0.6

-0.6

154

146

156

158

562

556

544

561

595

562

598

602

352

344

348

350

153

149

152

154

525

519

553

548

624

610

634

620

345

310

346

348

562

556

554

558

550

524

553

549

629

588

622

606

643

604

659

646

-1.7

-1.0

-1.0

-2.1

9.9

0

0

9.9

-1.4

-1.2

-1.2

-1.4

12.3

13.5

13.3

12.5

-1.4

-1.0

-0.9

-1.2

10.5

10.6

9.8

10.5

-1.3

-1.1

-1.1

-1.2

9.3

8.9

10.2

8.0

-0.9

-0.7

-0.9

-1.0

7.6

8.2

8.2

6.0

-0.9

-0.7

-0.8

-0.9

11.2

11.3

11.3

11.1

Test Time	8/30/77 BASELINE	8/27/77 BOOS I	8/31/77 BOOS II	8/28/77 BIAS I	9/1/77 BIAS II
FD Fan A Discharge Pres. (in H ₂ O) Gage	5.9	6.1	6.9	5.5	5.7
FD Fan B Discharge Pres. (in H ₂ O)	6.8	8.5	7.9	7.0	7.5
Gas Pres. Leaving Airheaters (in H ₂ O) Gage	2.8	3.9	3.6	2.9	3.2
Burner Box Pres. Superheater Furnace (in H ₂ O) Gage	2.1	2.7	3.0	2.2	2.3
Reheat Furnace (in H ₂ O)	2.2	3.1	2.9	2.3	2.6
ID Fan A Inlet Pres. (-in. H ₂ O) Gage	-11.2	-12.0	-11.3	-11.5	-10.0
ID Fan B Inlet Pres. (-in. H ₂ O)	-12.7	-12.6	-13.0	-12.0	-12.9
Furnace Draft Superheat (in H ₂ O) Gage	-0.5	-0.5	-0.5	-0.5	-0.5
Reheat (in H ₂ O)	-0.5	-0.4	-0.5	-0.5	-0.5
HT Superheater Differential Pres. (in H ₂ O) Gage	0.4	0.4	0.5	0.4	0.5
Reheater Differential Pres. (in H ₂ O)	1.1	1.0	1.0	0.9	0.8
DLT Superheater Differential Pres. SH (in H ₂ O)	1.4	1.1	1.3	1.2	1.4
RH (in H ₂ O)	1.6	1.9	1.9	1.7	1.6
Economizer Differential Pres. SH (in H ₂ O)	0.6	0.5	0.5	0.5	0.5
RH (in H ₂ O)	0.7	0.8	0.8	0.7	0.6
Airheater A Differential Pres. (in H ₂ O)	4.0	4.8	4.4	4.3	3.3
Airheater B Differential Pres. (in H ₂ O)	3.7	3.5	3.8	3.5	3.8
Fly Ash Collector A Differential Pres. (in H ₂ O)	3.3	3.4	3.1	3.3	2.6
Fly Ash Collector B Differential Pres. (in H ₂ O)	3.7	3.5	3.7	3.4	3.8
Reheat Furnace Burner Tilt (°+ or -) Gage	-15	-19	-13	-14	+7.8
Reheat Desup. Valve Position Left side	44	57	40	49	20
Right side	26	40	34	26	32
Superheat Furnace Burner Tilt (°+ or -) Gage	+10	+10	+10	+9	+10
Superheat Desuperheater Valve Position Left side	69	61	58	66	52
Right side	93	78	80	87	80
Pulverizer Amps A Gage	44	0	0	30	36
B	44	50	49	49	45
C	40	48	48	45	46
D	43	45	46	45	45
E	47	49	47	45	46
F	45	42	45	44	43

Date
Time
Test

Pulverizer Coal Feeder A (0-12) Gage

B (0-12)
C (0-12)
D (0-12)
E (0-12)
F (0-12)

Pulverizer Exhauster Damper A (0-12) Gage

B (0-12)
C (0-12)
D (0-12)
E (0-12)
F (0-12)

FD Fan A Amps Gage
ID Fan A Amps

FD Fan B Amps Gage
ID Fan B Amps

Air Flow Ratio SH (0-12) Gage
RH (0-12)

Blowdown Rate (lb/hr)

Relative Humidity Temp. DB (°F)
WB (°F)

Attenuator Flow SH Left (M lb/hr)
Rt. (M lb/hr)
RH Left (M lb/hr)
Rt. (M lb/hr)

8/30/77	8/29/77	8/31/77	8/28/77	9/1/77
BASELINE	BOOS I	BOOS II	BIAS I	BIAS II
5.6	0	0	0	0.7
5.7	6.9	6.7	7.2	5.6
5.9	7.7	7.4	7.9	6.5
5.9	6.8	5.6	6.6	5.0
6.1	7.1	5.5	6.6	5.0
6.8	6.7	5.8	7.1	5.3
5.5	0	0	3.4	4.5
6.3	7.5	7.3	7.9	6.2
6.1	8.0	7.6	8.0	6.8
8.1	7.2	8.1	7.0	6.3
9.5	6.9	9.5	6.3	9.5
7.2	7.0	6.1	7.5	5.6
55	54	56	54	54
130	130	128	130	115
61	65	64	62	63
138	132	140	131	138
3.8	3.8	3.8	3.8	3.8
3.6	3.6	3.6	3.6	3.6
0	0	0	0	0
76	74	75	73	74
NOT AVAILABLE				
INSTRUMENT NOT WORKING				
INSTRUMENT NOT WORKING				
INSTRUMENT NOT WORKING				
INSTRUMENT NOT WORKING				

SUMMARY SHEET

ASME TEST FORM
FOR ABBREVIATED EFFICIENCY TEST

PTC 4.1-a(1964)

OWNER OF PLANT <u>TVA</u>	TEST NO. <u>BASELINE</u> BOILER NO. <u>6</u> DATE <u>8/30/77</u>
TEST CONDUCTED BY	LOCATION <u>KINGSTON, TENN.</u>
BOILER, MAKE & TYPE	OBJECTIVE OF TEST
STOKER, TYPE & SIZE	DURATION
PULVERIZER, TYPE & SIZE	RATED CAPACITY
FUEL USED	BURNER, TYPE & SIZE
MINE	COUNTY
	STATE
	SIZE AS FIRED

PRESSURES & TEMPERATURES

		FUEL DATA	
1	STEAM PRESSURE IN BOILER DRUM	psia	
2	STEAM PRESSURE AT S. H. OUTLET	psia	
3	STEAM PRESSURE AT R. H. INLET	psia	
4	STEAM PRESSURE AT R. H. OUTLET	psia	
5	STEAM TEMPERATURE AT S. H. OUTLET	F	
6	STEAM TEMPERATURE AT R. H. INLET	F	
7	STEAM TEMPERATURE AT R. H. OUTLET	F	
8	WATER TEMP. ENTERING (ECON.) (BOILER)	F	
9	STEAM QUALITY % MOISTURE OR P. P. M.		
10	AIR TEMP. AROUND BOILER (AMBIENT)	F	
11	TEMP. AIR FOR COMBUSTION (This is Reference Temperature) †	F	
12	TEMPERATURE OF FUEL	F	
13	GAS TEMP. LEAVING (Boiler) (Econ.) (Air Htr.)	F	
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F	

UNIT QUANTITIES

15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb	
16	ENTHALPY OF (SATURATED) (SUPERHEATED) STM.	Btu/lb	
17	ENTHALPY OF SAT. FEED TO (BOILER) (ECON.)	Btu/lb	
18	ENTHALPY OF REHEATED STEAM R. H. INLET	Btu/lb	
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb	
20	HEAT ABS/LB OF STEAM (ITEM 16 - ITEM 17)	Btu/lb	
21	HEAT ABS/LB R. H. STEAM (ITEM 19 - ITEM 18)	Btu/lb	
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	0.20
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	374.4
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	0.626
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	11.29

HOURLY QUANTITIES

26	ACTUAL WATER EVAPORATED	lb/hr	
27	REHEAT STEAM FLOW	lb/hr	
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr	
29	TOTAL HEAT INPUT (Item 28 x Item 41) 1000	kB/hr	
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr	
31	TOTAL HEAT (Item 26 x Item 20) + (Item 27 x Item 21) + Item 30 OUTPUT 1000	kB/hr	

FLUE GAS ANAL. (BOILER) (ECON) (AIR HTR) OUTLET

32	CO ₂	% VOL	13.87
33	O ₂	% VOL	5.18
34	CO	% VOL	0
35	N ₂ (BY DIFFERENCE)	% VOL	80.95
36	EXCESS AIR	%	31.3

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

SUMMARY SHEET

ASME TEST FORM
FOR ABBREVIATED EFFICIENCY TEST

PTC 4.1-a (1964)

TEST NO. <i>8005 I</i> BOILER NO. <i>6</i> DATE <i>8/27/77</i>	
OWNER OF PLANT <i>TVA</i>	LOCATION <i>KINGSTON, TENN.</i>
TEST CONDUCTED BY	OBJECTIVE OF TEST
BOILER, MAKE & TYPE	RATED CAPACITY
STOKER, TYPE & SIZE	
PULVERIZER, TYPE & SIZE	BURNER, TYPE & SIZE
FUEL USED	MINE COUNTY STATE SIZE AS FIRED

PRESSURES & TEMPERATURES				FUEL DATA			
1	STEAM PRESSURE IN BOILER DRUM	psia		COAL AS FIRED PROX. ANALYSIS		% wt	OIL
2	STEAM PRESSURE AT S. H. OUTLET	psia		37	MOISTURE	<i>1.58</i>	51 FLASH POINT F*
3	STEAM PRESSURE AT R. H. INLET	psia		38	VOL MATTER	<i>32.1</i>	52 Sp. Gravity Deg. API*
4	STEAM PRESSURE AT R. H. OUTLET	psia		39	FIXED CARBON	<i>47.06</i>	53 VISCOSITY AT SSU* BURNER SSF
5	STEAM TEMPERATURE AT S. H. OUTLET	F		40	ASH	<i>19.26</i>	44 TOTAL HYDROGEN % wt
6	STEAM TEMPERATURE AT R. H. INLET	F		TOTAL		41	Btu per lb
7	STEAM TEMPERATURE AT R. H. OUTLET	F		41	Btu per lb AS FIRED	<i>11557</i>	<i>11545 @ const vol</i>
8	WATER TEMP. ENTERING (ECON.) (BOILER)	F		42	ASH SOFT TEMP.* ASTM METHOD		GAS % VOL
				COAL OR OIL AS FIRED ULTIMATE ANALYSIS		54	CO
10	AIR TEMP. AROUND BOILER (AMBIENT)	F		43	CARBON	<i>64.45</i>	55 CH ₄ METHANE
11	TEMP. AIR FOR COMBUSTION (This is Reference Temperature) †	F	<i>74</i>	44	HYDROGEN	<i>4.39</i>	56 C ₂ H ₂ ACETYLENE
12	TEMPERATURE OF FUEL	F	<i>74</i>	45	OXYGEN	<i>6.74</i>	57 C ₂ H ₄ ETHYLENE
13	GAS TEMP. LEAVING (Boiler) (Econ.) (Air Htr.)	F	<i>344</i>	46	NITROGEN	<i>1.13</i>	58 C ₂ H ₆ ETHANE
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F		47	SULPHUR	<i>2.40</i>	59 H ₂ S
				48	ASH	<i>19.26</i>	60 CO ₂
				49	MOISTURE	<i>1.58</i>	61 H ₂ HYDROGEN

UNIT QUANTITIES							
15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb		37	MOISTURE	<i>1.58</i>	61 H ₂ HYDROGEN
16	ENTHALPY OF (SATURATED) (SUPERHEATED) STM.	Btu/lb		TOTAL		TOTAL	
17	ENTHALPY OF SAT. FEED TO (BOILER) (ECON.)	Btu/lb		COAL PULVERIZATION		TOTAL HYDROGEN % wt	
18	ENTHALPY OF REHEATED STEAM R. H. INLET	Btu/lb		48	GRINDABILITY INDEX*	62	DENSITY 68 F ATM. PRESS.
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb		49	FINENESS % THRU 50 M*	63	Btu PER CU FT
20	HEAT ABS/LB OF STEAM (ITEM 16 - ITEM 17)	Btu/lb		50	FINENESS % THRU 200 M*	41	Btu PER LB
21	HEAT ABS/LB R. H. STEAM (ITEM 19 - ITEM 18)	Btu/lb		64	INPUT-OUTPUT EFFICIENCY OF UNIT %	ITEM 31 x 100 ITEM 29	
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	<i>0.20</i>	HEAT LOSS EFFICIENCY		Btu/lb A. F. FUEL	% of A. F. FUEL
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	<i>313.2</i>	65	HEAT LOSS DUE TO DRY GAS	<i>723.8</i>	<i>6.26</i>
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	<i>0.640</i>	66	HEAT LOSS DUE TO MOISTURE IN FUEL	<i>18.3</i>	<i>0.16</i>
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	<i>11.17</i>	67	HEAT LOSS DUE TO H ₂ O FROM COMB. OF H ₂	<i>458.5</i>	<i>3.97</i>
				68	HEAT LOSS DUE TO COMBUST. IN REFUSE	<i>62.6</i>	<i>0.54</i>
26	ACTUAL WATER EVAPORATED	lb/hr		69	HEAT LOSS DUE TO RADIATION	<i>33.0</i>	<i>0.29</i>
27	REHEAT STEAM FLOW	lb/hr		70	UNMEASURED LOSSES	<i>173.4</i>	<i>1.50</i>
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr		71	TOTAL		<i>1272</i>
29	TOTAL HEAT INPUT (Item 28 x Item 41) 1000	kB/hr		72	EFFICIENCY = (100 - Item 71)		<i>87.28</i>
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr					
31	TOTAL HEAT OUTPUT (Item 26 x Item 20) + (Item 27 x Item 21) + Item 30 1000	kB/hr					

HOURLY QUANTITIES			
26	ACTUAL WATER EVAPORATED	lb/hr	
27	REHEAT STEAM FLOW	lb/hr	
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr	
29	TOTAL HEAT INPUT (Item 28 x Item 41) 1000	kB/hr	
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr	
31	TOTAL HEAT OUTPUT (Item 26 x Item 20) + (Item 27 x Item 21) + Item 30 1000	kB/hr	
FLUE GAS ANAL. (BOILER) (ECON) (AIR HTR) OUTLET			
32	CO ₂	% VOL	<i>14.79</i>
33	O ₂	% VOL	<i>4.06</i>
34	CO	% VOL	<i>0</i>
35	N ₂ (BY DIFFERENCE)	% VOL	<i>81.15</i>
36	EXCESS AIR	%	<i>22.9</i>

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

SUMMARY SHEET

ASME TEST FORM
FOR ABBREVIATED EFFICIENCY TEST

PTC 4.1-a (1964)

OWNER OF PLANT <i>TVA</i>		TEST NO. <i>13005 II</i> BOILER NO. <i>6</i> DATE <i>8/3/77</i>	
TEST CONDUCTED BY		LOCATION <i>KINGSTON, TENN.</i>	
BOILER, MAKE & TYPE		OBJECTIVE OF TEST	
STOKER, TYPE & SIZE		DURATION	
PULVERIZER, TYPE & SIZE		RATED CAPACITY	
FUEL USED		BURNER, TYPE & SIZE	
MINE		COUNTY	
STATE		SIZE AS FIRED	

PRESSURES & TEMPERATURES

FUEL DATA

FUEL DATA									
1	STEAM PRESSURE IN BOILER DRUM	psia		COAL AS FIRED PROX. ANALYSIS		% wt		OIL	
2	STEAM PRESSURE AT S. H. OUTLET	psia		37	MOISTURE	2.58	51	FLASH POINT F°	
3	STEAM PRESSURE AT R. H. INLET	psia		38	VOL MATTER	31.68	52	Sp. Gravity Deg. API°	
4	STEAM PRESSURE AT R. H. OUTLET	psia		39	FIXED CARBON	47.25	53	VISCOSITY AT SSU* BURNER SSF	
5	STEAM TEMPERATURE AT S. H. OUTLET	F		40	ASH	18.49	44	TOTAL HYDROGEN % wt	
6	STEAM TEMPERATURE AT R. H. INLET	F		TOTAL			41	Btu per lb	
7	STEAM TEMPERATURE AT R. H. OUTLET	F		41	Btu per lb AS FIRED	11413	11402 @ Const Vol		
8	WATER TEMP. ENTERING (ECON.) (BOILER)	F		42	ASH SOFT TEMP.* ASTM METHOD		GAS % VOL		
9	STEAM QUALITY % MOISTURE OR P. P. M.			COAL OR OIL AS FIRED ULTIMATE ANALYSIS			54	CO	
10	AIR TEMP. AROUND BOILER (AMBIENT)	F		43	CARBON	64.0	55	CH ₄ METHANE	
11	TEMP. AIR FOR COMBUSTION (This is Reference Temperature) †	F	75	44	HYDROGEN	4.28	56	C ₂ H ₂ ACETYLENE	
12	TEMPERATURE OF FUEL	F	75	45	OXYGEN	7.11	57	C ₂ H ₄ ETHYLENE	
13	GAS TEMP. LEAVING (Boiler) (Econ.) (Air Htr.)	F	348	46	NITROGEN	1.38	58	C ₂ H ₆ ETHANE	
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F		47	SULPHUR	2.13	59	H ₂ S	
UNIT QUANTITIES				40	ASH	18.49	60	CO ₂	

UNIT QUANTITIES

15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb		37	MOISTURE	<i>2.58</i>	61	H ₂ HYDROGEN
16	ENTHALPY OF (SATURATED) (SUPERHEATED) STM.	Btu/lb			TOTAL			TOTAL
17	ENTHALPY OF SAT. FEED TO (BOILER) (ECON.)	Btu/lb			COAL PULVERIZATION			TOTAL HYDROGEN % wt
18	ENTHALPY OF REHEATED STEAM R. H. INLET	Btu/lb		48	GRINDABILITY INDEX*		62	DENSITY 68 F ATM. PRESS.
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb		49	FINENESS % THRU 50 M*		63	Btu PER CU FT
20	HEAT ABS/LB OF STEAM (ITEM 16 - ITEM 17)	Btu/lb		50	FINENESS % THRU 200 M*		41	Btu PER LB
21	HEAT ABS/LB R. H. STEAM (ITEM 19 - ITEM 18)	Btu/lb		64	INPUT-OUTPUT EFFICIENCY OF UNIT %			ITEM 31 x 100 ITEM 29
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	<i>0.19</i>		HEAT LOSS EFFICIENCY			Btu/lb A. F. FUEL
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	<i>427.8</i>	65	HEAT LOSS DUE TO DRY GAS			<i>734.5</i>
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	<i>0.634</i>	66	HEAT LOSS DUE TO MOISTURE IN FUEL			<i>30.3</i>
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	<i>11.21</i>	67	HEAT LOSS DUE TO H ₂ O FROM COMB. OF H ₂			<i>452.0</i>
				68	HEAT LOSS DUE TO COMBUST. IN REFUSE			<i>81.3</i>
				69	HEAT LOSS DUE TO RADIATION			<i>32.6</i>
				70	UNMEASURED LOSSES			<i>171.2</i>
				71	TOTAL			<i>13.16</i>
				72	EFFICIENCY = (100 - Item 71)			<i>86.84</i>

HOURLY QUANTITIES

26	ACTUAL WATER EVAPORATED	lb/hr		68	HEAT LOSS DUE TO COMBUST. IN REFUSE			<i>81.3</i>
27	REHEAT STEAM FLOW	lb/hr		69	HEAT LOSS DUE TO RADIATION			<i>32.6</i>
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr		70	UNMEASURED LOSSES			<i>171.2</i>
29	TOTAL HEAT INPUT (Item 28 x Item 41) 1000	kB/hr		71	TOTAL			<i>13.16</i>
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr		72	EFFICIENCY = (100 - Item 71)			<i>86.84</i>
31	TOTAL HEAT (Item 26 x Item 20) + (Item 27 x Item 21) + Item 30 OUTPUT 1000	kB/hr						

FLUE GAS ANAL. (BOILER) (ECON) (AIR HTR) OUTLET

32	CO ₂	% VOL	<i>14.56</i>
33	O ₂	% VOL	<i>4.40</i>
34	CO	% VOL	<i>0</i>
35	N ₂ (BY DIFFERENCE)	% VOL	<i>81.04</i>
36	EXCESS AIR	%	<i>22.4</i>

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

SUMMARY SHEET

ASME TEST FORM
FOR ABBREVIATED EFFICIENCY TEST

PTC 4.1-a(1964)

OWNER OF PLANT <i>TVA</i>				TEST NO. <i>BIAS I</i>		BOILER NO. <i>6</i>		DATE <i>8/28/77</i>	
TEST CONDUCTED BY				LOCATION <i>KINGSTON, TENN.</i>					
BOILER, MAKE & TYPE				OBJECTIVE OF TEST				DURATION	
STOKER, TYPE & SIZE				RATED CAPACITY					
PULVERIZER, TYPE & SIZE				BURNER, TYPE & SIZE					
FUEL USED		MINE		COUNTY		STATE		SIZE AS FIRED	

PRESSURES & TEMPERATURES				FUEL DATA					
1	STEAM PRESSURE IN BOILER DRUM	psia		COAL AS FIRED PROX. ANALYSIS		% wt		OIL	
2	STEAM PRESSURE AT S. H. OUTLET	psia		37	MOISTURE	<i>2.34</i>	51	FLASH POINT F°	
3	STEAM PRESSURE AT R. H. INLET	psia		38	VOL MATTER	<i>31.86</i>	52	Sp. Gravity Deg. API*	
4	STEAM PRESSURE AT R. H. OUTLET	psia		39	FIXED CARBON	<i>46.71</i>	53	VISCOSITY AT SSU* BURNER SSF	
5	STEAM TEMPERATURE AT S. H. OUTLET	F		40	ASH	<i>19.09</i>	44	TOTAL HYDROGEN % wt	
6	STEAM TEMPERATURE AT R. H. INLET	F		TOTAL			41	Btu per lb	
7	STEAM TEMPERATURE AT R. H. OUTLET	F		41	Btu per lb AS FIRED	<i>11345</i>	<i>11334 @ const vol</i>		
8	WATER TEMP. ENTERING (ECON.) (BOILER)	F		42	ASH SOFT TEMP.* ASTM METHOD		GAS % VOL		
9	STEAM QUALITY % MOISTURE OR P. P. M.			COAL OR OIL AS FIRED ULTIMATE ANALYSIS			54	CO	
10	AIR TEMP. AROUND BOILER (AMBIENT)	F		43	CARBON	<i>63.46</i>	55	CH ₄ METHANE	
11	TEMP. AIR FOR COMBUSTION (This is Reference Temperature) †	F	<i>73</i>	44	HYDROGEN	<i>4.24</i>	56	C ₂ H ₂ ACETYLENE	
12	TEMPERATURE OF FUEL	F	<i>73</i>	45	OXYGEN	<i>7.97</i>	57	C ₂ H ₄ ETHYLENE	
13	GAS TEMP. LEAVING (Boiler) (Econ.) (Air Htr.)	F	<i>354</i>	46	NITROGEN	<i>1.13</i>	58	C ₂ H ₆ ETHANE	
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F		47	SULPHUR	<i>1.75</i>	59	H ₂ S	
				48	ASH	<i>19.09</i>	60	CO ₂	
				37	MOISTURE	<i>2.34</i>	61	H ₂ HYDROGEN	
UNIT QUANTITIES				TOTAL		TOTAL			
15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb		COAL PULVERIZATION			TOTAL HYDROGEN % wt		
16	ENTHALPY OF (SATURATED) (SUPERHEATED) STM.	Btu/lb		48	GRINDABILITY INDEX*		62	DENSITY 68 F ATM. PRESS.	
17	ENTHALPY OF SAT. FEED TO (BOILER) (ECON.)	Btu/lb		49	FINENESS % THRU 50 M*		63	Btu PER CU FT	
18	ENTHALPY OF REHEATED STEAM R. H. INLET	Btu/lb		50	FINENESS % THRU 200 M*		41	Btu PER LB	
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb		64	INPUT-OUTPUT EFFICIENCY OF UNIT %	ITEM 31 × 100 ITEM 29			
20	HEAT ABS/LB OF STEAM (ITEM 16 - ITEM 17)	Btu/lb		HEAT LOSS EFFICIENCY			Btu/lb A. F. FUEL	% of A. F. FUEL	
21	HEAT ABS/LB R. H. STEAM (ITEM 19 - ITEM 18)	Btu/lb		65	HEAT LOSS DUE TO DRY GAS		<i>764.8</i>	<i>6.70</i>	
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	<i>0.20</i>	66	HEAT LOSS DUE TO MOISTURE IN FUEL		<i>27.6</i>	<i>0.24</i>	
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	<i>426.2</i>	67	HEAT LOSS DUE TO H ₂ O FROM COMB. OF H ₂		<i>450.0</i>	<i>3.74</i>	
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	<i>0.629</i>	68	HEAT LOSS DUE TO COMBUST. IN REFUSE		<i>852</i>	<i>0.75</i>	
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	<i>11.22</i>	69	HEAT LOSS DUE TO RADIATION		<i>32.4</i>	<i>0.28</i>	
HOURLY QUANTITIES				70	UNMEASURED LOSSES		<i>171.2</i>	<i>1.50</i>	
26	ACTUAL WATER EVAPORATED	lb/hr		71	TOTAL			<i>13.41</i>	
27	REHEAT STEAM FLOW	lb/hr		72	EFFICIENCY = (100 - Item 71)			<i>86.59</i>	
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr							
29	TOTAL HEAT INPUT (Item 28 × Item 41) 1000	kB/hr							
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr							
31	TOTAL HEAT OUTPUT (Item 26 × Item 20) + (Item 27 × Item 21) + Item 30 1000	kB/hr							
FLUE GAS ANAL. (BOILER) (ECON) (AIR HTR) OUTLET									
32	CO ₂	% VOL	<i>14.39</i>						
33	O ₂	% VOL	<i>4.71</i>						
34	CO	% VOL	<i>0</i>						
35	N ₂ (BY DIFFERENCE)	% VOL	<i>80.90</i>						
36	EXCESS AIR	%	<i>27.7</i>						

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

SUMMARY SHEET

ASME TEST FORM
FOR ABBREVIATED EFFICIENCY TEST

PTC 4.1-a(1964)

TEST NO. <i>BIAS II</i>		BOILER NO. <i>6</i>		DATE <i>9/1/77</i>	
OWNER OF PLANT <i>TVA</i>		LOCATION <i>KINGSTON, TENN.</i>			
TEST CONDUCTED BY		OBJECTIVE OF TEST		DURATION	
BOILER, MAKE & TYPE		RATED CAPACITY			
STOKER, TYPE & SIZE					
PULVERIZER, TYPE & SIZE		BURNER, TYPE & SIZE			
FUEL USED		MINE		COUNTY	
				STATE	
				SIZE AS FIRED	

PRESSURES & TEMPERATURES

FUEL DATA

PRESSURE & TEMPERATURES				FULL DATA				
1	STEAM PRESSURE IN BOILER DRUM	psia		COAL AS FIRED PROX. ANALYSIS		% wt	OIL	
2	STEAM PRESSURE AT S. H. OUTLET	psia		37	MOISTURE	1.97	51	FLASH POINT F*
3	STEAM PRESSURE AT R. H. INLET	psia		38	VOL MATTER	33.32	52	Sp. Gravity Deg. API*
4	STEAM PRESSURE AT R. H. OUTLET	psia		39	FIXED CARBON	50.12	53	VISCOSITY AT SSU* BURNER SSF
5	STEAM TEMPERATURE AT S. H. OUTLET	F		40	ASH	14.59	44	TOTAL HYDROGEN % wt
6	STEAM TEMPERATURE AT R. H. INLET	F		TOTAL			41	Btu per lb
7	STEAM TEMPERATURE AT R. H. OUTLET	F		41	Btu per lb AS FIRED	12258	12246 @ const 41	
8	WATER TEMP. ENTERING (ECON.) (BOILER)	F		42	ASH SOFT TEMP.* ASTM METHOD		GAS % VOL	
9	STEAM QUALITY % MOISTURE OR P. P. M.			COAL OR OIL AS FIRED ULTIMATE ANALYSIS			54	CO
10	AIR TEMP. AROUND BOILER (AMBIENT)	F		43	CARBON	68.33	55	CH ₄ METHANE
11	TEMP. AIR FOR COMBUSTION (This is Reference Temperature) †	F	74	44	HYDROGEN	4.62	56	C ₂ H ₂ ACETYLENE
12	TEMPERATURE OF FUEL	F	74	45	OXYGEN	7.71	57	C ₂ H ₄ ETHYLENE
13	GAS TEMP. LEAVING (Boiler) (Econ.) (Air Htr.)	F	350	46	NITROGEN	1.02	58	C ₂ H ₆ ETHANE
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F		47	SULPHUR	1.75	59	H ₂ S

UNIT QUANTITIES

15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb		37	MOISTURE	<i>1.97</i>	61	H ₂ HYDROGEN
16	ENTHALPY OF (SATURATED) (SUPERHEATED) STM.	Btu/lb			TOTAL			TOTAL
17	ENTHALPY OF SAT. FEED TO (BOILER) (ECON.)	Btu/lb			COAL PULVERIZATION			TOTAL HYDROGEN % wt
18	ENTHALPY OF REHEATED STEAM R. H. INLET	Btu/lb		48	GRINDABILITY INDEX*		62	DENSITY 68 F ATM. PRESS.
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb		49	FINENESS % THRU 50 M*		63	Btu PER CU FT
20	HEAT ABS/LB OF STEAM (ITEM 16 - ITEM 17)	Btu/lb		50	FINENESS % THRU 200 M*		41	Btu PER LB
21	HEAT ABS/LB R. H. STEAM (ITEM 19 - ITEM 18)	Btu/lb		64	INPUT-OUTPUT EFFICIENCY OF UNIT %			ITEM 31 x 100 ITEM 29
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	<i>0.15</i>		HEAT LOSS EFFICIENCY		Btu/lb A. F. FUEL	% of A. F. FUEL
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	<i>485.8</i>	65	HEAT LOSS DUE TO DRY GAS		<i>783.0</i>	<i>6.39</i>
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	<i>0.678</i>	66	HEAT LOSS DUE TO MOISTURE IN FUEL		<i>23.2</i>	<i>0.19</i>
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	<i>11.82</i>	67	HEAT LOSS DUE TO H ₂ O FROM COMB. OF H ₂		<i>189.0</i>	<i>3.99</i>
				68	HEAT LOSS DUE TO COMBUST. IN REFUSE		<i>72.9</i>	<i>0.59</i>
				69	HEAT LOSS DUE TO RADIATION		<i>35.0</i>	<i>0.29</i>
				70	UNMEASURED LOSSES		<i>183.9</i>	<i>1.50</i>
				71	TOTAL			<i>12.95</i>
				72	EFFICIENCY = (100 - Item 71)			<i>87.05</i>

HOURLY QUANTITIES

26	ACTUAL WATER EVAPORATED	lb/hr						
27	REHEAT STEAM FLOW	lb/hr						
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr						
29	TOTAL HEAT INPUT (Item 28 x Item 41) 1000	kB/hr						
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr						
31	TOTAL HEAT OUTPUT (Item 26 x Item 20) + (Item 27 x Item 21) + Item 30 1000	kB/hr						

FLUE GAS ANAL. (BOILER) (ECON) (AIR HTR) OUTLET

32	CO ₂	% VOL	<i>14.73</i>
33	O ₂	% VOL	<i>4.25</i>
34	CO	% VOL	<i>0</i>
35	N ₂ (BY DIFFERENCE)	% VOL	<i>81.02</i>
36	EXCESS AIR	%	<i>24.3</i>

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

APPENDIX B
ANALYTICAL PROCEDURES

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601 • AREA CODE 312 726-8434



Reply to

Instrumental Analysis Division
14335 West 44th Avenue
Golden, Colorado 80401

Phone: 303-278-9521

June 20, 1978

Mr. Brett Higginbotham
Acurex - Aerotherm
485 Clyde Avenue
Mountview, CA 94042

Re: IAD #97-A816-116-67

Analytical Report

The following report will describe the methodology used in analyzing all samples and also will include the precision attained.

In reference to IAD Batch No. 97-A816-116-67. All samples were analyzed according to the enclosed flow sheet, except for the elements listed in Table I.

Table I
Elements Analyzed by Flameless Atomic Absorption (Carbon Rod)

<u>Element</u>	<u>Type Sample</u>
Antimony	All impinger solutions
Arsenic	All impinger solutions
Mercury	All impinger solutions plus all waters and filtrates
Thallium	All samples
Tin	All samples
Zirconium	All samples

Table II will list by element the precision attained during the analysis.

Table II

<u>Element</u>	<u>Coal</u>	<u>Ash</u>	<u>Liquid</u>
Antimony (Sb)	<u>+1</u>	<u>+3</u>	<u>+0.005</u>
Arsenic (As)	<u>+0.5</u>	<u>+2</u>	<u>+0.01</u>
Barium (Ba)	<u>+100</u>	<u>+300</u>	<u>+0.2</u>
Beryllium (Be)	<u>+0.5</u>	<u>+2</u>	<u>+0.01</u>
Bismuth (Bi)	<u>+20</u>	<u>+70</u>	<u>+0.002</u>

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B-3



Table II (cont)

<u>Element</u>	<u>Coal</u>	<u>Ash</u>	<u>Liquid</u>
Boron (B)	<u>+8</u>	<u>+16</u>	<u>+0.1</u>
Cadmium (Cd)	<u>+0.6</u>	<u>+1.5</u>	<u>+0.01</u>
Chromium (Cr)	<u>+3</u>	<u>+11</u>	<u>+0.05</u>
Cobalt (Co)	<u>+10</u>	<u>+40</u>	<u>+0.05</u>
Copper (Cu)	<u>+1</u>	<u>+5</u>	<u>+0.02</u>
Iron (Fe)	<u>+100</u>	<u>+400</u>	<u>+0.05</u>
Lead (Pb)	<u>+7</u>	<u>+30</u>	<u>+0.1</u>
Manganese (Mn)	<u>+2</u>	<u>+7</u>	<u>+0.01</u>
Mercury (Hg)	<u>+0.01</u>	<u>+0.01</u>	<u>+0.01</u>
Molybdenum (Mo)	<u>+12</u>	<u>+65</u>	<u>+0.3</u>
Nickel (Ni)	<u>+3</u>	<u>+15</u>	<u>+0.03</u>
Selenium (Se)	<u>+0.5</u>	<u>+1.5</u>	<u>+0.01</u>
Tellurium (Te)	<u>+2</u>	<u>+6</u>	<u>+0.005</u>
Thallium (Tl)	<u>+1</u>	<u>+4</u>	<u>+0.01</u>
Tin (Sn)	<u>+10</u>	<u>+15</u>	<u>+0.05</u>
Titanium (Ti)	<u>+25</u>	<u>+100</u>	<u>+0.5</u>
Uranium (U)	<u>+3</u>	<u>+5</u>	<u>+0.1</u>
Vanadium (V)	<u>+10</u>	<u>+40</u>	<u>+0.2</u>
Zinc (Zn)	<u>+0.3</u>	<u>+1</u>	<u>+0.02</u>
Zirconium (Zr)	<u>+20</u>	<u>+75</u>	<u>+0.5</u>

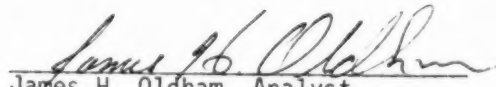
Table III will list the precision attained for all anions plus ammonium ion.

Table III

<u>Anion (Cation)</u>	<u>Solid</u>	<u>Soxhlet Extraction</u>	<u>Liquid</u>
Chloride		<u>+40</u>	<u>+0.1</u>
Fluoride		<u>+4</u>	<u>+0.01</u>
Nitrate		<u>+3</u>	<u>+0.05</u>
Cyanide		<u>+0.8</u>	<u>+0.003</u>
Sulfate	<u>+10</u>		<u>+0.5</u>
Ammonium		<u>+1</u>	<u>+0.02</u>



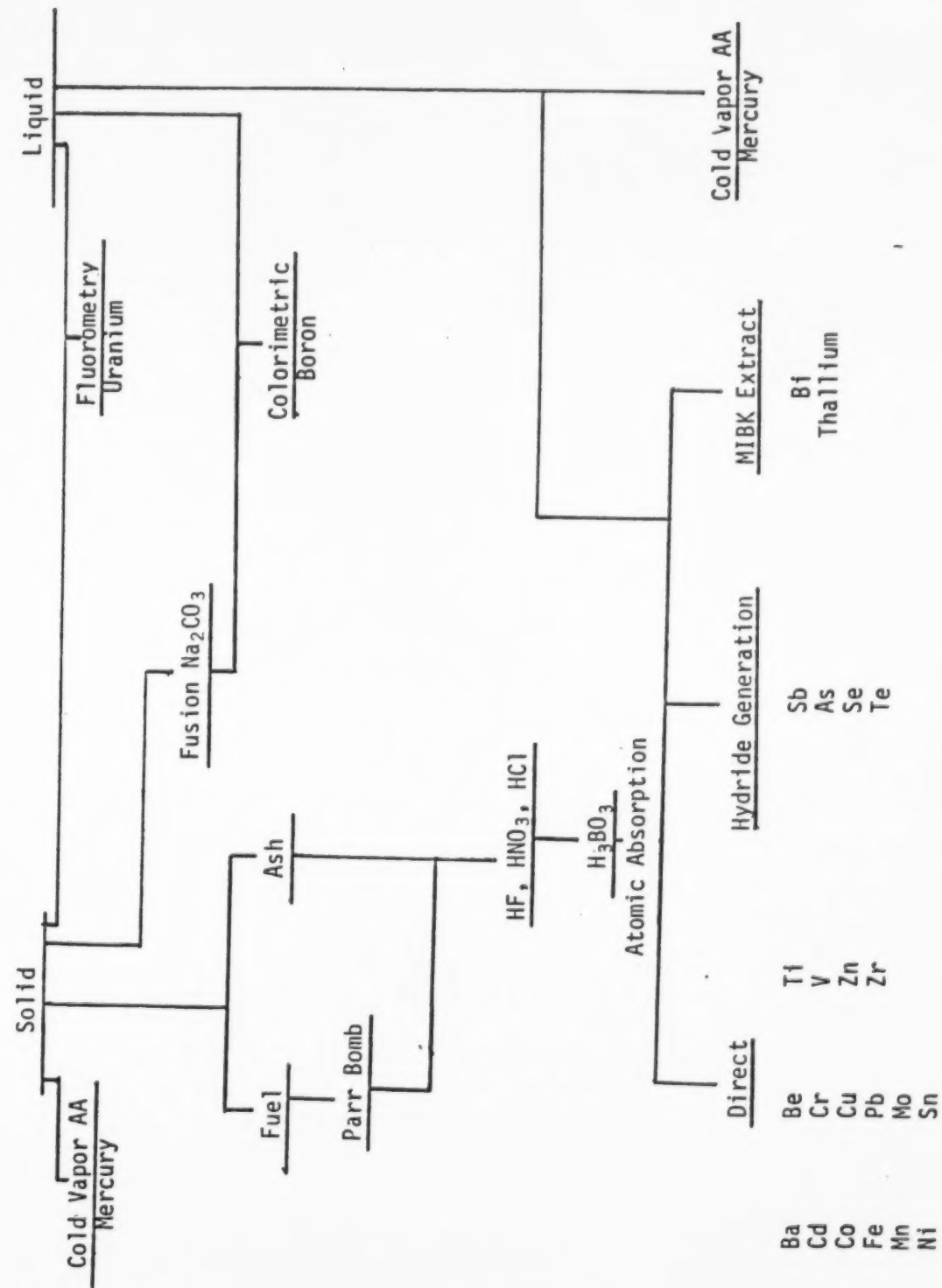
If you have any questions regarding this report please don't hesitate to call.


James H. Oldham, Analyst

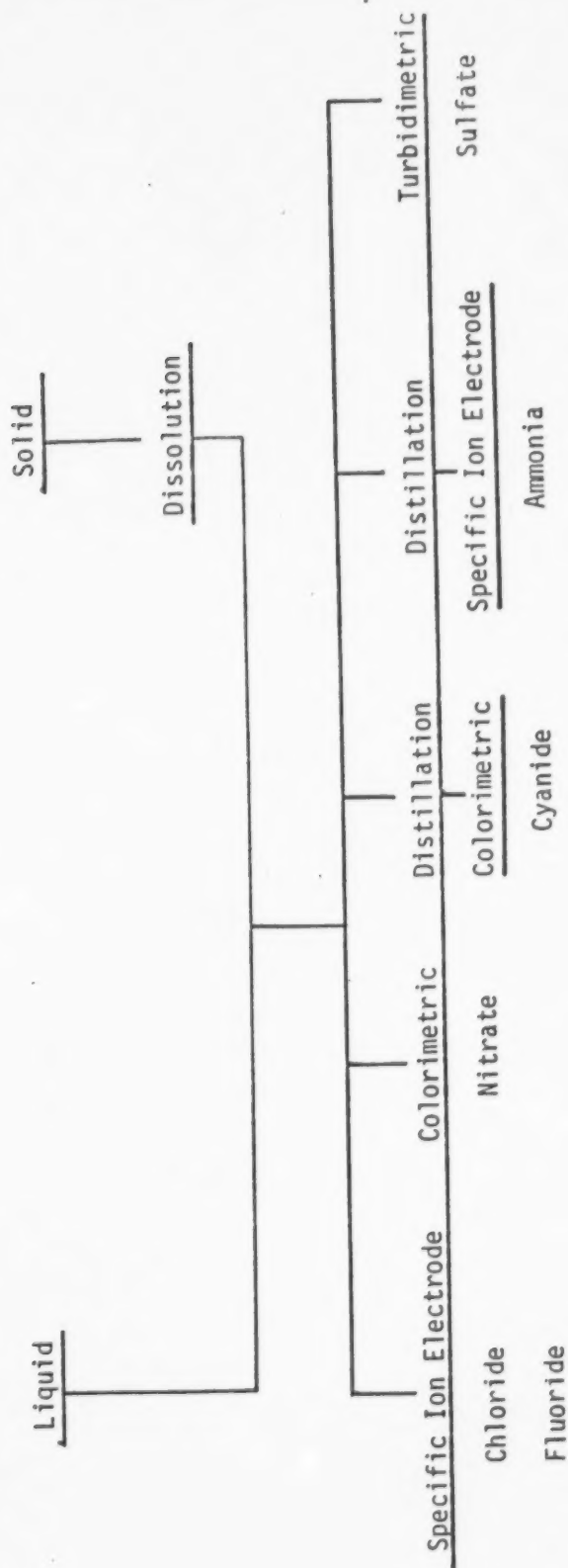

Approved:
M. L. Jacobs, Ph.D., Mngr.
Instrumental Analysis Division

JHO/ja

ELEMENTAL ANALYSIS FLOW SHEET



AMMONIA PLUS AMMONIA ANALYSIS FLOW SHEET



Level 1 Organic Analysis Procedure Modification

Pilot Studies Protocol

Reasons for this Modification:

The original Level 1 Organic Analysis Procedure, as specified in the June 1976 Procedures Manual, was designed in a manner which provided qualitative compound class identification and quantitative (gravimetric) data for those components of a sample that are retained when an organic sample extract is evaporated to dryness. For more volatile sample components, only quantitative information (quantities of material in defined boiling point ranges) was to be obtained. It was implicitly assumed that all compound with boiling points $\geq$ ca. 220°C (C_{13} and higher normal hydrocarbon range) would be retained and carried through the LC-IR-LRMS procedure, while those boiling below 220°C (C_{12} and lower normal hydrocarbons down to C_7^*) might be lost during sample evaporation to dryness.

New experimental data have shown that:

1. The range of material lost when the sample is evaporated to dryness for the gravimetric analysis and preparation of the LC sample is somewhat higher than anticipated: It is probably only C_{16} and higher (rather than C_{13} and higher) hydrocarbons that are retained. The C_{16} n-alkane boiling point is about 275°C.
2. Many of the compounds which are considered to be of concern in environmental assessment as a whole (not just Level 1) are in the boiling point range that would correspond to loss prior to LC, according to present procedures. Thus, no compound class information would be available from Level 1 to indicate the possible presence or to confirm the absence of significant amounts of these materials.

* $C_1 - C_6$ are to be done by on-site GC.

A revised procedure for Level 1 has been devised and subjected to limited experimental validation. The principal feature of this procedure, compared to the original, is that the organic extract is not evaporated to dryness prior to the LC and/or LRMS analyses. Two new sample handling steps are required:

- A quantitative assay procedure, TCO (total chromatographable organics) to complement the gravimetric analysis, and give quantitative data on C₇-C₁₆ range materials.
- A solvent exchange step to transfer the sample from a CH₂Cl₂ extract to a non-polar solvent and allow lower boiling material (> C₇) to go through LC and subsequent steps.

A new flow diagram is shown in Figure 1. The two new procedures are described on the following pages.

The total mass data for extracted samples is now taken as the sum of the value determined from the TCO and gravimetric assay. (TCO + GRAV)

Note that the C₇ - C₁₂ GC assay is now not required.

Both qualitative and quantitative data are expected to be obtained by this scheme for all materials boiling above the C₇ paraffin.

All other provisions, criteria and instructions of the Procedures Manual apply except for the noted changes.

TCO

Analyze a 1 μ l aliquot of solution by GC using a flame ionization detector. A 6 ft. x 1/8 in O.D. column of 10% OV-101 on 100/120 mesh Supelcoport has been used successfully for this analysis. Other silicon phases (OV-1, etc.) may work as well, but a 10% loading is recommended. The GC should be operated isothermally at about 30°C - or room temperature - for 5 minutes after sample injection and then programmed at approximately 20°C per minute to 250°C and held at 250°C as long as necessary for complete elution of sample.

Integrator should be set to begin integration at a time intermediate between the hexane (C₆) and heptane (C₇) peak maxima i.e. C_{6.5}) and terminate at the peak maxima of the heptadecane (C₁₇) peak, as determined from calibration standards. In this manner the integrated area will cover material in the boiling range of C₇-C₁₆.

Calibration should be done with a mixture containing a homologous series of hydrocarbons from C₇ to C₁₆. Standards should be prepared to cover the concentration range to be studied.

Solvent Exchange:

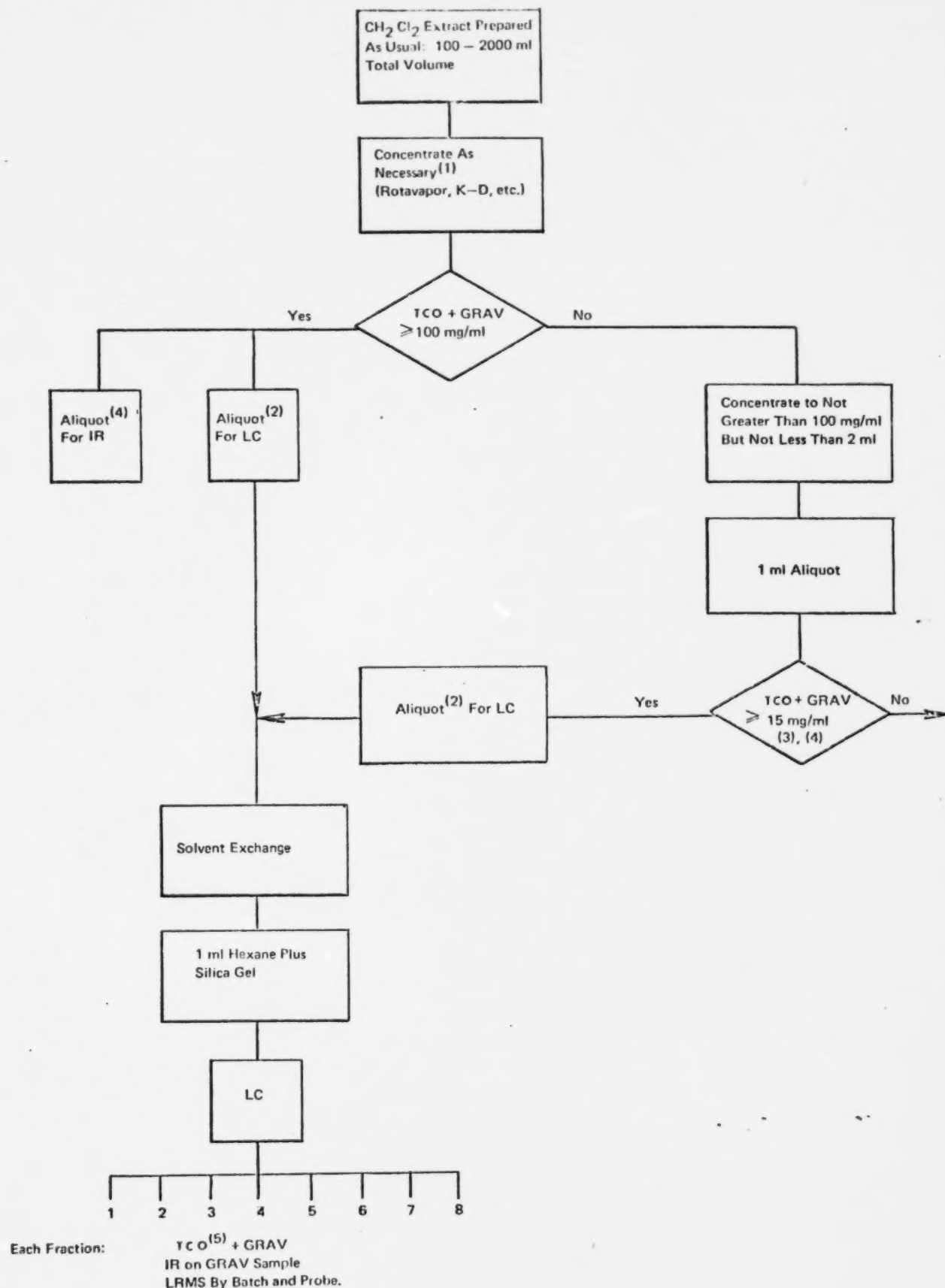
Place 1 - 5 ml of CH_2Cl_2 extract containing 15 - 100 mg of solute (TCO + GRAV), preferably 100 mg, in graduated centrifuge tube or K-D receiver. Add 200 mg of silica gel prepared as for the LC column. Evaporate if necessary to reduce volume to 1 ml.

Add 1 ml hexane and mix by gentle agitation. Again reduce volume to 1 ml by evaporation.

Add 1 ml more of hexane and mix. Reduce volume to 1 ml again.

Transfer hexane and silica gel (a Pasteur pipette works well) to top of previously prepared LC column.

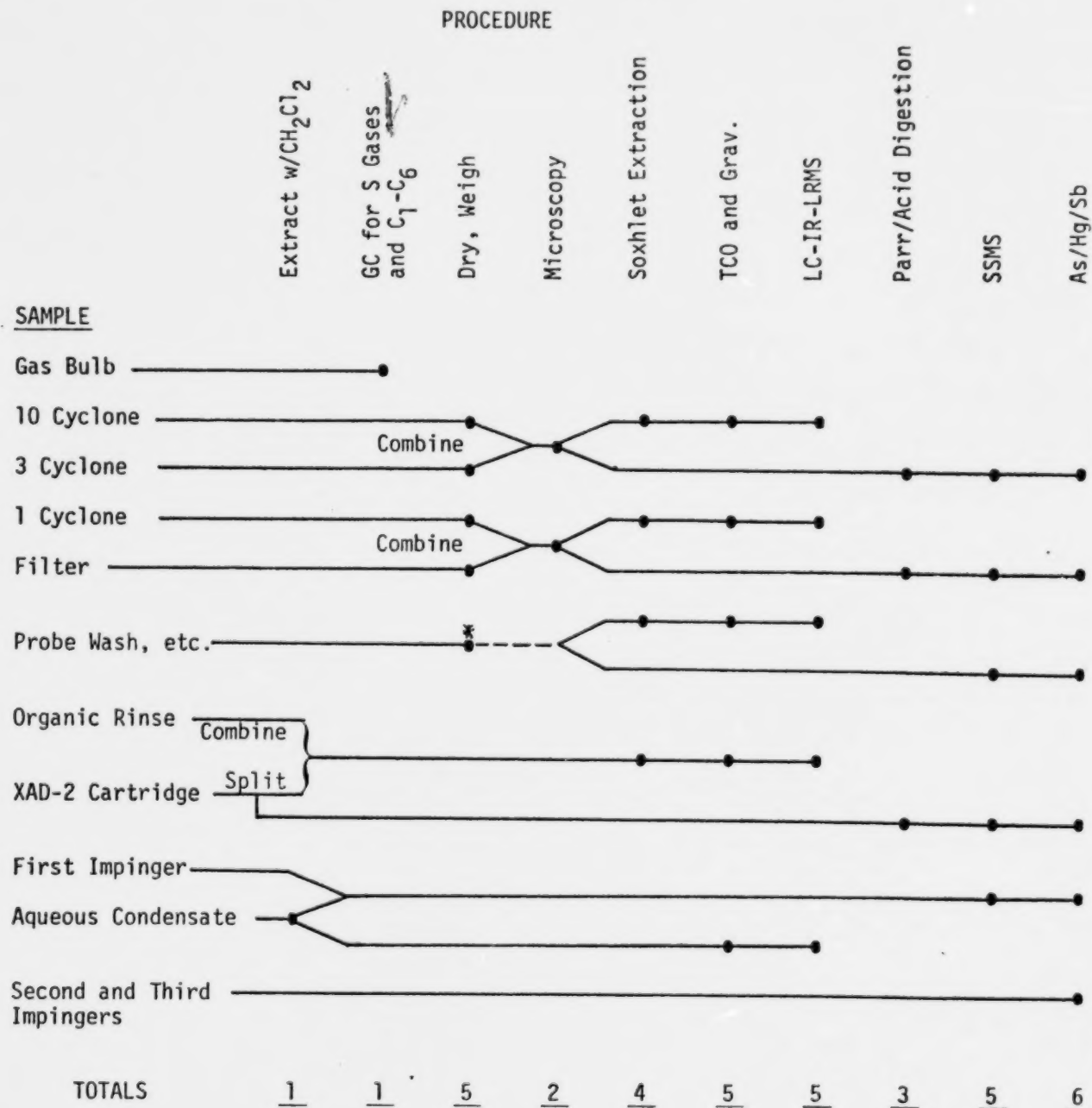
Run column as directed in Manual, rinsing graduated receiver with fresh solvents as they are introduced in the elution sequence.



Footnotes to Figure 1

- (1) Stop concentration if precipitate appears and add solvent to achieve complete solution.
- (2) Aliquot should be chosen to contain about 100 mg of material (TCO + GRAV) if possible, but not less than 15 mg, and be concentrated to 1 ml, if necessary.
- (3) If TCO value (alone) at this point is less than 2 mg/ml, then TCO assay and batch LRMS need not be done on LC fractions.
- (4) Obtain IR on GRAV assay sample.
- (5) It will be necessary to neutralize fraction 8 with NaOH before TCO.

Analytical Procedures Required for Gas/Particulate Environmental Assessment Samples



* This step is not in "Level 1 Procedures Manual", but is needed to define total mass of particulate catch. If the sample exceeds 10% of the total cyclone and filter sample weight proceed to analysis. If sample is less than 10% of catch, discard.

APPENDIX C
TRACE ELEMENT CONCENTRATIONS

Symbols appearing in the tables:

DSCM	Dry Standard Cubic Meter
ESP	Electrostatic Precipitator
KG	Kilogram
MCG	Microgram
MIN	Minute
PPM	Part per million by weight
<	Less than
*	Sample not analyzed for the particular element/or ionic specie
N	Sample not analyzed
-	Concentration in the sample is less than the concentration in the blank

TRACE ELEMENT ANALYSIS - (PPM) - COAL INLET

TRACE ELEMENTS	TEST CONDITION				
	BASELINE	BIOS1	BIOS 2	BIAS 1	BIAS 2
CATIONS					
ANTIMONY	.300	< 2.00	.400	< 2.00	< 2.00
ARSENIC	3.60	1.40	5.20	1.00	3.10
BARIUM	120.	90.0	159.	55.0	125.
BERYLLIUM	1.40	.700	1.00	.900	.900
BISMUTH	< .500-01	< .500	< .500-01	< .500	< .500
BORON	< 1.00	90.0	< 1.00	100.	90.0
CADMIUM	< .400	.300	< .400	.300	.300
CHROMIUM	26.0	15.0	38.0	10.0	15.0
CORALT	8.60	5.00	17.0	7.00	5.00
COPPER	24.0	20.0	20.0	21.0	23.0
IRON	.640+04	.133+05	.106+05	.940+04	.103+05
LEAD	14.0	4.00	14.0	5.00	5.00
MANGANESE	17.0	31.0	38.0	29.0	17.0
MERCURY	.500-01	.260	.900-01	.220	.290
MOLYBDENUM	.600	< 15.0	2.90	15.0	15.0
NICKEL	13.0	17.0	36.0	17.0	13.0
SELENIUM	3.80	.500	3.80	.500	.500
TELLURIUM	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
THALLIUM	< 1.00	< 2.00	< 1.00	< 2.00	< 2.00
TIN	< 140.	< 2.00	< 140.	< 2.00	< 2.00
TITANIUM	652.	.115+04	.109+04	.127+04	890.
URANIUM	< .500-03	< 10.0	< .500-03	< 10.0	< 10.0
VANADIUM	36.0	48.0	48.0	52.0	35.0
ZINC	21.0	17.0	18.0	20.0	10.0
ZIRCONIUM	< .300+05	120.	< 300.	260.	140.
ANIONS					
CHLORIDE	.000	.000	.000	.000	.000
FLUORIDE	.000	.000	.000	.000	.000
CYANIDE	.000	.000	.000	.000	.000
NITRATE	.000	.000	.000	.000	.000
SULFATE	.000	.000	.000	.000	.000
AMMONIUM	.000	.000	.000	.000	.000

TRACE ELEMENT ANALYSIS - (PPM) - BOTTOM ASH

TRACE ELEMENTS	CATIONS	BASELINE	TEST CONDITION			
			ROOSI	HOOS 2	BIAS 1	BIAS 2
CATIONS	ANTIMONY	< 3.00	< 3.00	< 3.00	< 3.00	N .000
	ARSENIC	< 4.00	< 5.00	< 5.00	< 3.00	N .000
	BARUM	< .240+04	< .270+04	< .260+04	< .200+04	N .000
	BERYLLIUM	< 10.0	< 10.0	< 10.0	< 10.0	N .000
	BISMUTH	< 70.0	< 70.0	< 70.0	< 70.0	N .000
	BORON	< 16.0	< 16.0	< 16.0	< 16.0	N .000
	CADMIUM	< 3.00	< 3.00	< 3.00	< 3.00	N .000
	CHROMIUM	< 160.	< 170.	< 160.	< 170.	N .000
	CORALIT	< 90.0	< 50.0	< 50.0	< 70.0	N .000
	COPPER	< 77.0	< 86.0	< 83.0	< 81.0	N .000
CATIONS	IRON	< .960+05	< .100+06	< .890+05	< .740+05	N .000
	LEAD	< 30.0	< 30.0	< 30.0	< 30.0	N .000
	MANGANESE	< 280.	< 230.	< 170.	< 200.	N .000
	MERCURY	< .200-01	< .800-01	< .700-01	< .800-01	N .000
	MOLYBDENUM	< 70.0	< 70.0	< 70.0	< 70.0	N .000
	NICKEL	< 65.0	< 65.0	< 60.0	< 110.	N .000
	SELENIUM	< 2.00	< 2.00	< 2.00	< 2.00	N .000
	TELLURIUM	< 20.0	< 6.00	< 8.00	< 6.00	N .000
	THALLIUM	< .500	< .500	< .500	< .500	N .000
	TIN	< 1.00	< 3.00	< 1.00	< 1.00	N .000
CATIONS	TITANIUM	< .920+04	< .910+04	< .920+04	< .910+04	N .000
	URANIUM	< 6.00	< 7.00	< 5.00	< 5.00	N .000
	VARADIUM	< 170.	< 190.	< 170.	< 180.	N .000
	ZINC	< 37.0	< 43.0	< 31.0	< 35.0	N .000
	ZIRCONIUM	< 420.	< 400.	< 340.	< 330.	N .000
ANIONS	CHLORIDE	< 100.	< 140.	< 100.	< 93.0	N .000
	FLUORIDE	< 12.0	< 12.0	< 120.	< 28.0	N .000
	CYANIDE	< .100+00	< 2.00	< .400	< .100+00	N .000
	NITRATE	< 2.00	< 430.	< 2.00	< 2.00	N .000
	SULFATE	< 500.	< .100+00	< 400.	< 530.	N .000
	AMMONIUM	< 1.00	< 3.00	< 1.00	< 1.00	N .000

TRACE ELEMENT ANALYSIS - (PPM) - MECH. HOPPER ASH

TRACE ELEMENTS		TEST CONDITION			
CATIONS	BASELINE	HOOS 1	HOOS 2	BIAS 1	BIAS 2
ANTIMONY	<	<	<	<	N .000
ARSENIC	3.00	3.00	3.00	3.00	N .000
BARIUM	40.0	40.0	40.0	35.0	N .000
BERYLLIUM	.300+04	.100+05	.290+04	.240+04	N .000
BISMUTH	10.0	11.0	12.0	10.0	N .000
BORON	70.0	70.0	70.0	70.0	N .000
CADMIUM	100.	130.	160.	190.	N .000
CHROMIUM	3.00	3.00	3.00	3.00	N .000
CORAL	170.	160.	190.	160.	N .000
COPPER	60.0	60.0	60.0	60.0	N .000
	115.	104.	154.	105.	N .000
IRON	.780+05	.720+05	.760+05	.490+05	N .000
LEAD	30.0	30.0	30.0	30.0	N .000
MANGANESE	190.	130.	140.	130.	N .000
MERCURY	.200-01	.400-01	.200-01	.400-01	N .000
MOLYBDENUM	70.0	70.0	70.0	70.0	N .000
NICKEL	65.0	65.0	70.0	55.0	N .000
SELENIUM	<	<	<	3.00	N .000
TELLURIUM	<	<	<	6.00	N .000
THALLIUM	<	<	<	.500	N .000
TIN	2.00	3.00	1.00	1.00	N .000
TITANIUM	.980+04	.104+05	.107+05	.990+04	N .000
URANIUM	6.00	5.00	6.00	5.00	N .000
VANADIUM	240.	240.	250.	230.	N .000
ZINC	79.0	92.0	79.0	63.0	N .000
ZIRCONIUM	10.0	130.	140.	150.	N .000
ANIONS					
CHLORIDE	140.	170.	90.0	170.	N .000
FLUORIDE	28.0	12.0	11.0	8.00	N .000
CYANIDE	<	<	<	.100+00	N .000
NITRATE	<	<	<	2.00	N .000
SULFATE	.170+04	730.	.150+04	.100+04	N .000
AMMONIUM	<	11.0	2.00	22.0	N .000

TRACE ELEMENT ANALYSIS - (PPM) - BOILER OUTLET ASH
10 & 3 MICRON CYCLONES

TRACE ELEMENTS

CATIONS	BASELINE	BOOS1	TEST CONDITION			
			BOOS 2	BIAS 1	BIAS 2	
ANTIMONY	< 3.00	< 3.00	< 3.00	< 3.00	< 3.00	
ARSENIC	90.0	95.0	95.0	95.0	100.	
BARIUM	.280+04	.320+04	.710+04	.230+04	.290+04	
BERYLLIUM	12.0	11.0	15.0	14.0	17.0	
BISMUTH	< 70.0	< 70.0	< 70.0	< 70.0	< 70.0	
BORON	* .000	* .000	* .000	* .000	* .000	
CADMIUM	< 3.00	< 3.00	< 3.00	< 3.00	< 3.00	
CHROMIUM	180.	210.	230.	210.	250.	
CORALY	80.0	60.0	60.0	70.0	90.0	
COPPER	158.	204.	160.	184.	234.	
IRON	.620+05	.620+05	.630+05	.470+05	.540+05	
LEAD	40.0	60.0	50.0	70.0	90.0	
MANGANESE	210.	160.	130.	150.	140.	
MERCURY	.130	.110	.100+00	.120	.780	
MOLYBCENUM	< 70.0	< 70.0	< 70.0	< 70.0	< 70.0	
NICKEL	90.0	115.	110.	128.	130.	
SELENIUM	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	
TELLURIUM	< 6.00	10.0	50.0	15.0	70.0	
THALLIUM	< 4.00	< 4.00	< 4.00	< 4.00	< 4.00	
TIN	20.0	10.0	10.0	< 10.0	25.0	
TITANIUM	.960+04	.910+04	.960+04	.870+04	.103+05	
URANIUM	5.00	5.00	5.00	5.00	7.00	
VANADIUM	260.	270.	240.	260.	300.	
ZINC	160.	170.	140.	200.	190.	
ZIRCONIUM	370.	570.	.130+04	80.0	390.	
ANIONS						
CHLORIDE	160.	120.	320.	170.	160.	
FLUORIDE	33.0	22.0	41.0	160.	350.	
CYANIDE	< .800	< .700	< 1.00	< .800	.900	
NITRATE	< 3.00	< 2.00	< 5.00	< 3.00	< 3.00	
SULFATE	.410+04	.300+04	.280+04	.190+04	.260+04	
AMMONIUM	< 1.00	3.00	9.00	< 1.00	6.00	

TRACE ELEMENT ANALYSIS - (PPM) - BOILER OUTLET ASH
1 MICRON & FILTER

TRACE ELEMENTS	BASELINE	TEST CONDITION			
		BOOS1	HOOS 2	BIAS 1	BIAS 2
CATIONS					
ANTIMONY	6.00	6.00	7.00	4.00	14.0
ARSENIC	250.	150.	140.	140.	150.
BARIUM	.340+04	.390+04	.350+04	.270+04	.350+04
BERYLLIUM	15.0	14.0	18.0	16.0	20.0
BISMUTH	< 70.0	< 70.0	< 70.0	< 70.0	< 70.0
BORON	* .000	* .000	* .000	* .000	* .000
CADMIUM	< 3.00	< 3.00	< 3.00	< 3.00	< 3.00
CHROMIUM	310.	370.	290.	280.	370.
COBALT	80.0	110.	120.	80.0	100.
COPPER	212.	225.	268.	220.	287.
IRON	.580+05	.580+05	.550+05	.470+05	.510+05
LEAD	130.	150.	160.	110.	140.
MANGANESE	240.	240.	190.	170.	160.
MERCURY	.120	.510	.100+00	.190	.210
MOLYBDENUM	90.0	140.	120.	90.0	130.
NICKEL	125.	160.	160.	130.	150.
SELENIUM	< 2.00	< 2.00	< 2.00	< 2.00	< 3.00
TELLURIUM	70.0	80.0	10.0	< 6.00	15.0
THALLIUM	< 4.00	< 4.00	< 4.00	< 4.00	< 4.00
TIN	15.0	< 10.0	< 10.0	< 10.0	< 10.0
TITANIUM	.960+04	.960+04	.960+04	.920+04	.104+05
URANIUM	5.00	5.00	8.00	5.00	6.00
VANADIUM	410.	390.	410.	330.	450.
ZINC	350.	410.	420.	310.	330.
ZIRCONIUM	230.	.120+04	75.0	190.	870.
ANIONS					
CHLORIDE	480.	680.	650.	130.	.150+04
FLUORIDE	58.0	610.	110.	96.0	230.
CYANIDE	< 2.00	< 3.00	< 3.00	< .500	1.00
NITRATE	< 6.00	< 8.00	< 10.0	< 2.00	.100+04
SULFATE	.730+04	.880+04	.920+04	.840+04	.450+04
AMMONIUM	< 4.00	< 4.00	< 5.00	4.00	77.0

TRACE ELEMENT ANALYSIS - (PPM) - BOILER OUTLET ASH
XAD-2 CARTRIDGE

TRACE ELEMENTS	TEST CONDITION				
	CATIONS	BASLINE	ROOS1	BOOS 2	BIAS 1
	ANTIMONY	N .000	N .000	N .000	N .000
	ARSENIC	N .000	N .000	N .000	N .000
	BARIUM	N .000	N .000	N .000	N .000
	BERYLLIUM	N .000	N .000	N .000	N .000
	BISMUTH	N .000	N .000	N .000	N .000
	BORON	N .000	N .000	N .000	N .000
	CAESIUM	N .000	N .000	N .000	N .000
	CHROMIUM	N .000	N .000	N .000	N .000
	COBALT	N .000	N .000	N .000	N .000
	COPPER	N .000	N .000	N .000	N .000
	IRON	N .000	N .000	N .000	N .000
	LEAD	N .000	N .000	N .000	N .000
	MANGANESE	N .000	N .000	N .000	N .000
	MERCURY	N .000	N .000	N .000	N .000
	MOLYBDENUM	N .000	N .000	N .000	N .000
	NICKEL	N .000	N .000	N .000	N .000
	SELENIUM	N .000	N .000	N .000	N .000
	TELLURIUM	N .000	N .000	N .000	N .000
	THALLIUM	N .000	N .000	N .000	N .000
	TIN	N .000	N .000	N .000	N .000
	TITANIUM	N .000	N .000	N .000	N .000
	URANIUM	N .000	N .000	N .000	N .000
	VANADIUM	N .000	N .000	N .000	N .000
	ZINC	N .000	N .000	N .000	N .000
	ZIRCONIUM	N .000	N .000	N .000	N .000
ANIONS	CHLORIDE	N .000	N .000	N .000	N .000
	FLUORIDE	N .000	N .000	N .000	N .000
	CYANIDE	N .000	N .000	N .000	N .000
	NITRATE	N .000	N .000	N .000	N .000
	SULFATE	N .000	N .000	N .000	N .000
	AMMONIUM	N .000	N .000	N .000	N .000

TRACE ELEMENT ANALYSIS - (PPM) - ROILER OUTLET ASH
FIRST IMPINGER

TRACE ELEMENTS	CATIONS	BASELINE	TEST CONDITION			
			ROOS1	ROOS 2	BIAS 1	BIAS 2
CATIONS	ANTIMONY	.000	.000	.000	.000	.000
	ARSENIC	.220	.150	.180	.290	.120
	BARIUM	.000	.000	.000	.000	.000
	BERYLLIUM	<	< .100-01	< .100-01	<	< .100-01
	BISMUTH	<	< .200	< .200	<	< .200
	BORON	5.60	8.60	15.6	7.60	20.6
	CADMIUM	<	< .100-01	< .100-01	<	< .100-01
	CHROMIUM	26.4	14.3	28.0	30.0	27.1
	COBALT	.670	.470	.570	.670	.670
	COPPER	8.90	.820	14.0	3.40	3.00
CATIONS	IRON	115.	74.6	120.	143.	135.
	LEAD	.540	< .100+00	1.00	.200	.200
	MANGANESE	1.48	.980	1.67	2.20	1.94
	MERCURY	.000	.000	.000	.000	.000
	MOLYBDENUM	4.00	2.00	3.00	2.00	2.00
	NICKEL	17.0	8.60	17.0	18.0	15.0
	SELENIUM	.140	2.10	.280	.900-01	.800-01
	TELLURIUM	.000	.000	.000	.000	.000
	THALLIUM	.000	.000	.000	.000	.000
	TIN	.000	.000	.000	.000	.000
CATIONS	TITANIUM	.000	.000	.000	.000	.000
	URANIUM	.000	.000	.000	.000	.000
	VANADIUM	.000	.000	.000	.000	.000
	ZINC	19.0	1.57	16.0	5.97	8.57
	ZIRCONIUM	.300	2.40	.300	.300	.300
ANIONS	CHLORIDE	.000	.000	.000	.000	.000
	FLUORIDE	.000	.000	.000	.000	.000
	CYANIDE	.000	.000	.000	.000	.000
	NITRATE	.000	.000	.000	.000	.000
	SULFATE	.000	.000	.000	.000	.000
	AMMONIUM	.000	.000	.000	.000	.000

TRACE ELEMENT ANALYSIS - (PPM) - BOILER OUTLET ASH
2ND & 3RD IMPINGERS

TRACE ELEMENTS	CATIONS	TEST CONDITION			
		BASELINE	BOOS 1	BOOS 2	BIAS 1
	ANTIMONY	.600-01	.100-01	.300-02	.300-02
	ARSENIC	.900-02	.260-01	.800-02	.290-01
	BARIUM	.000	*	.000	.000
	BERYLLIUM	.000	*	.000	.000
	BISMUTH	.000	*	.000	.000
	BORON	.000	*	.000	.000
	CADMIUM	.000	*	.000	.000
	CHROMIUM	.000	*	.000	.000
	COBALT	.000	*	.000	.000
	COPPER	.000	*	.000	.000
	IRON	.000	*	.000	.000
	LEAD	.000	*	.000	.000
	MANGANESE	.000	*	.000	.000
	MERCURY	.120	*	.000	.000
	MOLYBDENUM	.000	.400-01	.200	.500-01
	NICKEL	.000	.000	.000	.000
	SELENIUM	.000	.000	.000	.000
	TELLURIUM	.000	.000	.000	.000
	THALLIUM	.000	.000	.000	.000
	TIN	.000	.000	.000	.000
	TITANIUM	.000	.000	.000	.000
	URANIUM	.000	.000	.000	.000
	VANADIUM	.000	.000	.000	.000
	ZINC	.000	.000	.000	.000
	ZIRCONIUM	.000	.000	.000	.000
	ANIONS				
	CHLORIDE	.000	.000	.000	.000
	FLUORIDE	.000	.000	.000	.000
	CYANIDE	.000	.000	.000	.000
	NITRATE	.000	.000	.000	.000
	SULFATE	.000	.000	.000	.000
	AMMONIUM	.000	.000	.000	.000

TRACE ELEMENT ANALYSIS - (PPM) - ESP HOPPER ASH

TRACE ELEMENTS	TEST CONDITION				
	BASELINE	BOOS1	BOOS 2	BIAS 1	BIAS 2
CATIONS					
ANTIMONY	< 3.00	< 3.00	< 3.00	< 3.00	N .000
ARSENIC	130.	130.	120.	100.	N .000
BARIUM	.280+04	.120+05	.290+04	.320+04	N .000
BERYLLIUM	12.0	13.0	13.0	14.0	N .000
BISMUTH	< 70.0	< 70.0	< 70.0	< 70.0	N .000
BORON	< 16.0	< 16.0	< 16.0	< 16.0	N .000
CADMIUM	< 3.00	< 3.00	< 3.00	< 3.00	N .000
CHROMIUM	180.	190.	200.	190.	N .000
CORAL	60.0	60.0	70.0	60.0	N .000
COPPER	160.	151.	195.	162.	N .000
IRON	.620+05	.640+05	.570+05	.490+05	N .000
LEAD	60.0	80.0	70.0	76.0	N .000
MANGANESE	200.	180.	160.	160.	N .000
MERCURY	.600-01	.110	.160	.150	N .000
MOLYBDENUM	90.0	< 70.0	< 80.0	< 70.0	N .000
NICKEL	90.0	90.0	100.	100.	N .000
SELENIUM	3.00	3.00	3.00	4.00	N .000
TELLURIUM	< 6.00	7.00	< 6.00	< 6.00	N .000
THALLIUM	< .500	< .500	< .500	< .500	N .000
TIN	< 1.00	< 3.00	< 1.00	< 1.00	N .000
TITANIUM	.960+04	.950+04	.101+05	.100+05	N .000
URANIUM	6.00	10.0	8.00	5.00	N .000
VANADIUM	300.	300.	300.	270.	N .000
ZINC	180.	200.	190.	170.	N .000
ZIRCONIUM	< 10.0	65.0	< 10.0	65.0	N .000
ANIONS					
CHLORIDE	60.0	53.0	57.0	70.0	N .000
FLUORIDE	47.0	120.	28.0	53.0	N .000
CYANIDE	< .100+00	< .100+00	< .100+00	< .100+00	N .000
NITRATE	< 2.00	< 2.00	< 2.00	< 2.00	N .000
SULFATE	.520+04	.510+04	.440+04	.460+04	N .000
AMMONIUM	61.0	38.0	2.00	2.00	N .000

TRACE ELEMENT ANALYSIS - (PPM) - FLYASH OUTLET
10 & 3 MICRON CYCLONES

TRACE ELEMENTS	BASELINE	TEST CONDITION			
		BOOS1	BOOS 2	BIAS 1	BIAS 2
CATIONS					
ANTIMONY	5.00	N .000	N .000	< 3.00	5.00
ARSENIC	130.	N .000	N .000	95.0	120.
BARIUM	.340+04	N .000	N .000	.220+04	.300+04
BERYLLIUM	13.0	N .000	N .000	15.0	16.0
BISMUTH	< 70.0	N .000	N .000	< 70.0	< 70.0
BORON	* .000	N .000	N .000	* .000	* .000
CADMIUM	< 3.00	N .000	N .000	< 3.00	< 3.00
CHROMIUM	230.	N .000	N .000	250.	270.
COBALT	80.0	N .000	N .000	80.0	90.0
COPPER	186.	N .000	N .000	183.	260.
IRON	.590+05	N .000	N .000	.460+05	.550+05
LEAD	80.0	N .000	N .000	90.0	110.
MANGANESE	210.	N .000	N .000	160.	160.
MERCURY	.130	N .000	N .000	.800-01	.200
MOLYBDENUM	80.0	N .000	N .000	< 70.0	< 70.0
NICKEL	105.	N .000	N .000	145.	140.
SELENIUM	5.00	N .000	N .000	4.00	8.00
TELLURIUM	6.00	N .000	N .000	< 6.00	< 6.00
THALLIUM	4.00	N .000	N .000	< 4.00	< 4.00
TIN	10.0	N .000	N .000	< 10.0	< 10.0
TITANIUM	.950+04	N .000	N .000	.850+04	.102+05
URANIUM	5.00	N .000	N .000	10.0	6.00
VANADIUM	360.	N .000	N .000	270.	360.
ZINC	210.	N .000	N .000	250.	260.
ZIRCONIUM	230.	N .000	N .000	390.	.160+04
ANIONS					
CHLORIDE	430.	N .000	N .000	480.	370.
FLUORIDE	120.	N .000	N .000	760.	320.
CYANIDE	2.00	N .000	N .000	< 400	< 2.00
NITRATE	6.00	N .000	N .000	< 7.00	< 270.
SULFATE	.780+04	N .000	N .000	.530+04	.910+04
AMMONIUM	3.00	N .000	N .000	5.00	96.0

TRACE ELEMENT ANALYSIS - (PPM) - FLYASH OUTLET
1 MICRON & FILTER

TRACE ELEMENTS	BASELINE	ROOS1	ROOS 2	BIAS 1	BIAS 2
CATIONS					
ANTIMONY	6.00	7.00	<	5.00	8.00
ARSENIC	150.	130.	<	140.	140.
BARIUM	.360+04	.230+04	<	.310+04	.320+04
BERYLLIUM	15.0	12.0	<	17.0	21.0
BISMUTH	<	<	<	70.0	70.0
BORON	* .000	* .000	*	.000	.000
CADMIUM	<	<	<	3.00	3.00
CHROMIUM	320.	300.	390.	300.	440.
CORALY	50.0	90.0	120.	80.0	120.
COPPER	220.	368.	330.	236.	325.
IRON	.610+05	.520+05	.540+05	.500+05	.550+05
LEAD	140.	250.	120.	160.	220.
MANGANESE	250.	210.	180.	200.	200.
MERCURY	.150	.110	.220	.100+00	.170
MOLYBDENUM	130.	80.0	130.	100.	160.
NICKEL	135.	140.	210.	140.	190.
SELENIUM	4.00	10.0	12.0	5.00	8.00
TELLURIUM	<	60.0	7.00	6.00	6.00
THALLIUM	<	6.00	5.00	4.00	4.00
TIN	<	15.0	12.0	10.0	10.0
TITANIUM	.970+04	.680+04	.840+04	.850+04	.105+05
URANIUM	7.00	7.00	5.00	13.0	10.0
VANADIUM	450.	310.	370.	440.	580.
ZINC	390.	320.	350.	450.	490.
ZIRCONIUM	<	.140+04	.160+04	390.	390.
ANIONS					
CHLORIDE	410.	.470+04	.200+04	790.	270.
FLUORIDE	140.	360.	270.	190.	140.
CYANIDE	<	2.00	3.00	<	400.
NITRATE	<	.160+04	.190+04	83.0	230.
SULFATE	.120+05	.400+04	.490+04	.640+04	.160+05
AMMONIUM	12.0	250.	340.	19.0	250.

TRACE ELEMENT ANALYSIS - (PPM) - FLYASH OUTLET
XAD-2 CARTRIDGE

TRACE ELEMENTS	TEST CONDITION				
	CATIONS	BASLINE	BOUS1	BOUS 2	BIAS 1
CATIONS	ANTIMONY	< 1.00	< 2.00	< 1.00	< 1.00
	ARSENIC	< .000	< 4.00	< .000	< 1.00
	BARIUM	< 100.	< 160.	< 100.	< 100.
	BERYLLIUM	< 3.00	< 9.00	< 3.00	< 5.00
	BISMUTH	< 20.0	< 50.0	< 24.0	< 31.0
	BORON	< 5.00	< 62.0	< 5.00	< 53.0
	CADMIUM	< .600	< 3.00	< .600	< 2.00
	CHROMIUM	< .000	< .000	< .000	< .000
	CORALT	< 10.0	< 18.0	< 10.0	< 11.0
	COPPER	< .000	< 5.00	< .000	< 3.00
CATIONS	IRON	< .000	< 66.0	< .000	< 107.
	LEAD	< 7.00	< 19.0	< 7.00	< 11.0
	MANGANESE	< .000	< .000	< .000	< .000
	MERCURY	< .330	< .460	< .350	< .590
	MOLYBDCENUM	< 12.0	< 91.0	< 10.0	< .000
	NICKEL	< 19.0	< 13.0	< 8.00	< 140.
	SELENIUM	< .000	< .000	< .000	< .000
	TELLURIUM	< 2.00	< 1.00	< 2.00	< 1.00
	THALLIUM	< 1.00	< 28.0	< 1.00	< 17.0
	TIN	< 2.10	< 109.	< 2.10	< 27.0
CATIONS	TITANIUM	< .000	< 17.0	< .000	< 1.00
	URANIUM	< 3.00	< 5.00	< 3.00	< 7.00
	VANADIUM	< 20.0	< .000	< 20.0	< .000
	ZINC	< 8.00	< 23.0	< 4.00	< 25.0
	ZIRCONIUM	< 25.0	< 64.0	< 5.00	< 34.0
ANIONS	CHLORIDE	< .000	< .000	< .000	< .000
	FLUORIDE	< .000	< .000	< .000	< .000
	CYANIDE	< .000	< .000	< .000	< .000
	NITRATE	< .000	< .000	< .000	< .000
	SULFATE	< .000	< .000	< .000	< .000
	AMMONIUM	< .000	< .000	< .000	< .000

TRACE ELEMENT ANALYSIS - (PPM) - FLYASH OUTLET
2ND & 3RD IMPINGERS

TRACE ELEMENTS	CATIONS	BASELINE	TEST CONDITION			
			HOOS1	HOOS 2	BIAS 1	BIAS 2
ANTIMONY	ARSENIC	.100-02	.000	.000	.200-02	.200-02
	BARUM	.500-02	.150-01	.190-01	.240-01	.290-01
	BERYLLIUM	.000	*	.000	.000	.000
	BISMUTH	.000	*	.000	.000	.000
	BORON	.000	*	.000	.000	.000
COPPER	CADMIUM	.000	*	.000	.000	.000
	CHROMIUM	.000	*	.000	.000	.000
	CORALT	.000	*	.000	.000	.000
	COPPER	.000	*	.000	.000	.000
	IRON	.000	*	.000	.000	.000
LEAD	LEAD	.000	*	.000	.000	.000
	MANGANESE	.000	*	.000	.000	.000
	MERCURY	.000	*	.000	.000	.000
	MOLYBDENUM	.000	*	.000	.000	.000
	NICKEL	.000	*	.000	.000	.000
SELENIUM	SELENIUM	.000	*	.000	.000	.000
	TELLURIUM	.000	*	.000	.000	.000
	THALLIUM	.000	*	.000	.000	.000
	TIN	.000	*	.000	.000	.000
	TITANIUM	.000	*	.000	.000	.000
URANIUM	URANIUM	.000	*	.000	.000	.000
	VANADIUM	.000	*	.000	.000	.000
	ZINC	.000	*	.000	.000	.000
	ZIRCONIUM	.000	*	.000	.000	.000
	ANIONS					
CHLORIDE	CHLORIDE	.000	*	.000	.000	.000
	FLUORIDE	.000	*	.000	.000	.000
	CYANIDE	.000	*	.000	.000	.000
	NITRATE	.000	*	.000	.000	.000
	SULFATE	.000	*	.000	.000	.000
AMMONIUM	AMMONIUM	.000	*	.000	.000	.000

APPENDIX D
TRACE ELEMENT FLOW RATES

Symbols appearing in the tables:

DSCM	Dry Standard Cubic Meter
ESP	Electrostatic Precipitator
KG	Kilogram
MCG	Microgram
MIN	Minute
PPM	Part per million by weight
<	Less than
*	Sample not analyzed for the particular element/or ionic specie
N	Sample not analyzed
-	Concentration in the sample is less than the concentration in the blank

APPENDIX D-1
TRACE ELEMENT FLOW RATES
(kilograms per minute)

TRACE ELEMENT MASS FLOWRATE (KG/MIN) - BASELINE

TRACE ELEMENTS		STREAM LOCATION						
CATIONS	COAL	BOTTOM ASH	MECHANICAL HOPPER ASH	INLET FLYASH	INLET VAPOR	ESP HOPPER ASH	OUTLET FLYASH	OUTLET VAPOR
ANTIMONY	.156-03	< .610-04	< .187-03	< .972-04	.290-04	< .474-04	.185-04	< .268-04
ARSENIC	.187-02	.813-04	.249-02	.334-02	.874-04	.205-02	.470-03	< .225-04
BARIUM	.623-01	.488-01	.187	.775-01	.000	.442-01	.117-01	< .251-02
BERYLLIUM	.726-03	.203-03	.622-03	.335-03	< .378-05	.189-03	.470-04	< .774-04
BISMUTH	< .259-04	< .142-02	< .435-02	< .185-02	< .755-04	< .111-02	< .232-03	< .543-03
BORON	< .519-03	< .325-03	.622-02	* .000	.211-02	< .253-03	* .000	< .126-03
CADMIUM	< .208-03	< .610-04	< .187-03	< .792-04	< .378-05	< .474-04	< .993-05	< .171-04
CHROMIUM	.135-01	.325-02	.106-01	.553-02	.997-02	.284-02	.940-03	< .734-02
CORALIT	.446-02	.163-02	.373-02	.211-02	.253-03	.947-03	.206-03	< .379-03
COPPER	.125-01	.157-02	.715-02	.449-02	.336-02	.253-02	.684-03	< .772-03
IRON	3.32	1.95	4.85	1.61	.438-01	.979	.200	< .350-01
LEAD	< .726-02	< .610-03	< .187-02	.160-02	.204-03	.947-03	.583-03	< .196-03
MANGANESE	.882-02	.569-02	.118-01	.572-02	.559-03	.316-02	.775-03	< .470-03
MERCURY	.259-04	.407-06	.124-05	.337-05	.580-04	.947-06	.470-06	.829-05
MOLYBDENUM	.311-03	< .142-02	< .435-02	< .197-02	.151-02	.142-02	.564-03	< .708-03
NICKEL	.674-02	.132-02	.404-02	.259-02	.642-02	.142-02	.407-03	< .373-02
SELENIUM	.197-02	< .407-04	< .124-03	< .526-04	.529-04	.474-04	.146-04	< .366-04
TELLURIUM	< .519-03	.407-03	< .373-03	< .544-03	.000	< .947-04	< .199-04	< .517-04
THALLIUM	< .519-03	< .102-04	< .311-04	< .106-03	.000	< .789-05	< .133-04	< .251-04
TIN	< .726-01	< .203-04	.124-03	.498-03	- .000	< .158-04	< .332-04	< .528-04
TITANIUM	.338	.187	.609	.253	.000	.155	.319-01	- .000
URANIUM	< .259-06	.122-03	.373-03	< .132-03	- .000	.947-04	< .205-04	< .754-04
VANADIUM	.187-01	.346-02	.149-01	.776-02	- .000	.474-02	.137-02	< .502-03
ZINC	.109-01	.752-03	.491-02	.537-02	.717-02	.284-02	.105-02	.113-02
ZIRCONIUM	< 15.6	.854-02	< .622-03	.892-02	< .113-03	< .158-03	.457-03	.689-03
ANIONS								
CHLORIDE	* .000	.203-02	.871-02	.615-02	* .000	.947-03	.139-02	.000
FLUORIDE	* .000	.244-03	.174-02	.102-02	* .000	.742-03	.437-03	.000
CYANIDE	* .000	< .203-05	< .622-05	< .283-04	* .000	< .158-05	< .663-05	.000
NITRATE	* .000	< .407-04	< .124-03	< .972-04	* .000	< .316-04	< .199-04	.000
SULFATE	* .000	.102-01	.106	.127	* .000	.821-01	.541-01	.000
AMMONIUM	* .000	< .203-04	< .622-04	< .445-04	* .000	.963-03	< .277-04	.000

TRACE ELEMENT MASS FLOWRATE (KG/MIN) - ROOSI

TRACE ELEMENTS CATIONS	STREAM LOCATION							
	COAL	BOTTOM ASH	MECHANICAL HOPPER ASH	INLET FLYASH	INLET VAPOR	ESP HOPPER ASH	OUTLET FLYASH	OUTLET VAPOR
ANTIMONY	< .923-03	< .533-04	< .192-03	< .798-04	.448-05	< .120-04	.683-05	.655-04
ARSENIC	.646-03	.889-04	.256-02	.237-02	.663-04	.521-03	.127-03	.167-03
BARIUM	.415-01	.480-01	.640	.750-01	.000	.461-01	.224-02	.504-02
BERYLLIUM	.323-03	.178-03	.704-03	.262-03	< .358-05	.521-04	.117-04	< .288-03
BISMUTH	< .231-03	< .124-02	< .448-02	< .159-02	< .716-04	< .281-03	< .683-04	< .166-02
BORON	.415-01	< .284-03	.832-02	* .000	.308-02	< .641-04	* .000	.852-02
CADMIUM	< .138-03	< .533-05	< .192-03	< .681-04	< .358-05	< .120-04	< .293-05	< .987-04
CHROMIUM	.692-02	.502-02	.102-01	.539-02	.513-02	.762-03	.293-03	.909-02
COPALT	.231-02	.889-03	.512-02	.156-02	.168-03	.321-03	.878-04	.765-03
COPPER	.923-02	.153-02	.691-02	.472-02	.294-03	.605-03	.559-03	.747-03
IRON	6.14	1.78	4.61	1.39	.267-01	.257	.507-01	.446-01
LEAD	.185-02	< .533-03	< .192-02	.171-02	< .358-04	.321-03	.244-03	.682-03
MANGANESE	.143-01	.409-02	.832-02	.432-02	.351-03	.722-03	.205-03	.623-03
MERCURY	.120-03	.142-05	.256-05	.405-05	.179-04	.441-06	.107-06	.158-03
MOLYBCENUM	< .692-02	< .124-02	< .448-02	< .186-02	.716-03	< .261-03	.781-04	.329-02
NICKEL	.785-02	.116-02	.416-02	.279-02	.308-02	.361-03	.137-03	.449-02
SELENIUM	< .231-03	< .356-04	< .128-03	< .454-04	.752-03	.120-04	.976-05	.126-04
TELLURIUM	< .482-03	< .107-03	< .384-03	.499-03	.000	.281-04	.586-04	.315-04
THALLIUM	< .923-03	< .889-05	< .320-04	< .909-04	.000	< .200-05	< .586-05	.882-03
TIN	< .923-03	.533-04	.192-03	< .227-03	- .000	< .120-04	< .146-04	- .343-02
TITANIUM	.531	.162	.665	.209	.000	.381-01	.684-02	.535-03
URANIUM	< .462-02	.128-03	< .320-03	< .114-03	- .000	.401-04	.683-05	- .157-03
VANADIUM	.222-01	.338-02	.154-01	.660-02	- .000	.120-02	.303-03	- .000
ZINC	.785-02	.765-03	.588-02	.479-02	.552-03	.802-03	.412-03	.214-02
ZIRCONIUM	.554-01	.711-02	.832-02	.154-01	.860-03	.261-03	.137-02	.259-02
ANIONS								
CHLORIDE	* .000	.249-02	.109-01	.490-02	* .000	.212-03	.459-02	* .000
FLUORIDE	* .000	.213-03	.768-03	.278-02	* .000	.481-03	.551-03	* .000
CYANIDE	* .000	< .356-04	< .640-05	< .248-04	* .000	< .401-06	< .195-05	* .000
NITRATE	* .000	.765-02	< .128-03	< .687-04	* .000	< .802-05	.156-02	* .000
SULFATE	* .000	< .178-05	.467-01	.907-01	* .000	.204-01	.590-02	* .000
AMMONIUM	* .000	.533-04	.704-03	.720-04	* .000	.152-03	.244-03	* .000

TRACE ELEMENT MASS FLOWRATE (KG/MIN) - BOOS 2

TRACE ELEMENTS		STREAM LOCATION						
CATIONS	COAL	BOTTOM ASH	MECHANICAL HOPPER ASH	INLET FLYASH	INLET VAPOR	ESP HOPPER ASH	OUTLET FLYASH	OUTLET VAPOR
ANTIMONY	.285-03	< .527-04	< .164-03	< .854-04	.130-05	< .404-04	< .132-04	< .49A-04
ARSENIC	.247-02	.878-04	.219-02	.230-02	.711-04	.162-02	.559-03	- .394-04
BARIUM	.755-01	.457-01	.159	.138	.000	.391-01	.112-01	< .459-02
BERYLLIUM	.475-03	.176-03	.657-03	.309-03	< .376-05	.175-03	.559-04	< .143-03
BISMUTH	< .238-04	< .123-02	< .383-02	< .153-02	< .752-04	< .944-03	< .230-03	.120-02
BORON	< .475-03	< .281-03	.876-02	* .000	.511-02	< .216-03	* .000	< .435-02
CADMIUM	< .190-03	< .527-04	< .164-03	< .657-04	< .376-05	< .404-04	< .986-05	< .323-04
CHROMIUM	.181-01	.281-02	.104-01	.533-02	.278-02	.270-02	.128-02	- .105-01
COPALT	.808-02	.878-03	.329-02	.195-02	.214-03	.944-03	.695-03	< .636-03
COPPER	.950-02	.146-02	.734-02	.404-02	.526-02	.263-02	.109-02	- .862-03
IRON	5.04	1.56	4.16	1.34	.451-01	.768	.178	- .439-01
LEAD	< .665-02	< .527-03	< .164-02	.164-02	.376-03	.944-03	.595-03	< .369-03
MANGANESE	.181-01	.299-02	.767-02	.348-02	.628-03	.216-02	.592-03	- .527-03
MERCURY	.428-04	.123-05	.110-05	.219-05	.864-04	.216-05	.723-06	.161-04
MOLYBDENUM	.134-02	< .123-02	< .583-02	< .178-02	.113-02	< .108-02	.427-03	< .429-02
NICKEL	.171-01	.105-02	.383-02	.266-02	.639-02	.135-02	.691-03	< .707-02
SELENIUM	.181-02	< .351-04	< .110-03	< .438-04	.105-03	.404-04	.595-04	- .000
TELLURIUM	< .475-03	< .141-03	< .329-03	.898-03	.000	< .809-04	< .230-04	< .952-04
THALLIUM	< .475-03	< .878-05	< .274-04	< .876-04	.000	< .674-05	< .164-04	< .459-04
TIN	< .665-01	< .176-04	< .548-04	< .219-03	- .000	< .135-04	< .595-04	< .964-04
TITANIUM	.520	.162	.586	.210	.000	.136	.276-01	- .000
URANIUM	< .238-06	< .878-04	.329-03	< .124-03	.000	.108-03	< .164-04	< .138-03
VANADIUM	.228-01	.299-02	.126-01	.609-02	.000	.404-02	.122-02	< .918-03
ZINC	.855-02	.545-03	.433-02	.445-02	.600-02	.256-02	.115-02	.323-02
ZIRCONIUM	< .143	.597-02	.767-02	.224-01	< .113-03	< .135-03	.526-02	< .373-03
ANIONS								
CHLORIDE	* .000	.176-02	.493-02	.863-02	* .000	.768-03	.658-02	.000
FLUORIDE	* .000	.211-02	.603-03	.124-02	* .000	.378-03	.888-03	.000
CYANIDE	* .000	< .703-05	< .219-04	< .318-04	* .000	< .135-05	.986-05	.000
NITRATE	* .000	< .351-04	< .110-03	< .134-03	* .000	< .270-04	.592-02	.000
SULFATE	* .000	.703-02	.712-01	.110	* .000	.593-01	.161-01	.000
AMMONIUM	* .000	< .176-04	.110-03	.177-03	* .000	.270-04	.112-02	.000

TRACE ELEMENT MASS FLOWRATE (KG/MIN) - BIAS 1

TRACE ELEMENTS	STREAM LOCATION							
	COAL	BOTTOM ASH	MECHANICAL HOPPER ASH	INLET FLYASH	INLET VAPOR	ESP HOPPER ASH	OUTLET FLYASH	OUTLET VAPOR
ANTIMONY	< .104-02	< .598-04	< .183-03	< .652-04	.127-05	< .486-04	< .142-04	.262-04
ARSENIC	.522-03	.598-04	.213-02	.208-02	.134-03	.162-02	.420-03	.328-04
BARIUM	.267-01	.399-01	.146	.496-01	.000	.518-01	.950-02	.256-02
BERYLLIUM	.470-03	.199-03	.609-03	.302-03	< .419-05	.227-03	.598-04	< .130-03
BISMUTH	< .261-03	< .140-02	< .426-02	< .150-02	< .638-04	< .113-02	< .257-03	< .640-03
BORON	.522-01	< .319-03	.116-01	* .000	.318-02	< .259-03	* .000	.136-02
CADMIUM	< .157-03	< .596-04	.183-03	< .642-04	< .419-05	< .486-04	< .110-04	< .535-04
CHROMIUM	.522-02	.339-02	.978-02	.457-02	.126-01	.308-02	.997-03	.145-02
CORAL	.365-02	.140-02	.365-02	.151-02	.281-03	.971-03	.294-03	.388-03
COPPER	.110-01	.161-02	.639-02	.397-02	.142-02	.262-02	.756-03	.105-02
IRON	4.91	1.48	2.98	1.01	.599-01	.793	.175	.101-01
LEAD	.261-02	< .598-03	.183-02	.154-02	.638-04	.123-02	.473-03	< .305-03
MANGANESE	.151-01	.399-02	< .791-02	.323-02	.922-03	.259-02	.651-03	.791-04
MERCURY	.115-03	.159-05	.243-05	.264-05	.211-04	.243-05	.325-06	.151-04
MOLYBDENUM	< .783-02	< .140-02	< .426-02	< .152-02	.638-03	< .113-02	< .504-03	- .000
NICKEL	.888-02	.219-02	.335-02	.258-02	.754-02	.162-02	.525-03	.442-02
SELENIUM	< .261-03	< .399-04	.183-03	< .428-04	.377-04	.648-04	.163-04	.256-04
TELLURIUM	< .522-03	< .120-03	< .365-03	.311-03	.000	< .971-04	< .220-04	< .179-04
THALLIUM	< .104-02	< .997-05	< .304-04	< .856-04	.000	< .809-05	< .147-04	.436-03
TIN	< .104-02	< .199-04	.609-04	< .214-03	- .000	< .162-04	< .567-04	- .692-03
TITANIUM	.663	.181	.603	.187	.000	.162	.512-01	.256-04
URANIUM	< .522-02	< .997-04	< .304-03	< .107-03	- .000	.809-04	.415-04	- .179-03
VANADIUM	.271-01	.359-02	.140-01	.604-02	- .000	.437-02	.126-02	- .000
ZINC	.104-01	.698-03	.383-02	.439-02	.250-02	.275-02	.123-02	.141-02
ZIRCONIUM	.136	.658-02	.791-02	.183-02	< .126-03	.105-02	.143-02	< .871-03
ANIONS								
CHLORIDE	* .000	.185-02	.103-01	.359-02	* .000	.113-02	.225-02	* .000
FLUORIDE	* .000	.558-03	.487-03	.336-02	* .000	.858-03	.149-02	* .000
CYANIDE	* .000	< .199-05	< .609-05	< .168-04	* .000	< .162-05	< .163-05	* .000
NITRATE	* .000	< .399-04	< .122-03	< .631-04	* .000	< .324-04	< .146-03	* .000
SULFATE	* .000	.106-01	.609-01	.475-01	* .000	.745-01	.212-01	* .000
AMMONIUM	* .000	< .199-04	.134-02	< .245-04	* .000	.324-04	.404-04	* .000

TRACE ELEMENT MASS FLOWRATE (KG/MIN) - BIAS 2

TRACE ELEMENTS		STREAM LOCATION						
CATIONS	COAL	BOTTOM ASH	MECHANICAL HOPPER ASH	INLET FLYASH	INLET VAPOR	ESP HOPPER ASH	OUTLET FLYASH	OUTLET VAPOR
ANTIMONY	< .959-03	Q .000	.000	< .513-04	.164-05	.000	.866-05	.390-04
ARSENIC	.149-02	Q .000	.000	.146-02	.534-04	.000	.177-03	.136-03
BARIUM	.599-01	Q .000	.000	.403-01	.000	.000	.423-02	.500-02
BERYLLIUM	.431-03	Q .000	.000	.245-03	< .363-05	.000	.249-04	< .271-03
BISMUTH	< .240-03	Q .000	.000	< .998-03	< .726-04	.000	< .959-04	< .166-02
BORON	.431-01	Q .000	.000	* .000	.747-02	.000	* .000	.606-02
CADMIUM	< .144-03	Q .000	.000	< .428-04	< .363-05	.000	< .411-05	.185-03
CHROMIUM	.719-02	Q .000	.000	.366-02	.984-02	.000	.472-03	.510-02
CORALIT	.240-02	Q .000	.000	.129-02	.243-03	.000	.141-03	.673-03
COPPER	.110-01	Q .000	.000	.338-02	.109-02	.000	.595-03	.665-03
IRON	.4.94	Q .000	.000	.767	.483-01	.000	.754-01	.250-01
LEAD	.240-02	Q .000	.000	.132-02	.726-04	.000	.217-03	< .598-03
MANGANESE	.815-02	Q .000	.000	.201-02	.704-03	.000	.243-03	.360-03
MERCURY	.139-03	Q .000	.000	.107-04	.000	.000	.256-06	.112-04
MOLYBDENUM	< .719-02	Q .000	.000	< .104-02	.726-03	.000	< .150-03	.333-02
NICKEL	.623-02	Q .000	.000	.187-02	.544-02	.000	.222-03	.267-02
SELENIUM	< .240-03	Q .000	.000	< .293-04	.290-04	.000	.110-04	.614-05
TELLURIUM	< .479-03	Q .000	.000	.955-03	.000	.000	< .822-05	.385-04
THALLIUM	< .959-03	Q .000	.000	< .570-04	.000	.000	< .548-05	.845-03
TIN	< .959-03	Q .000	.000	.345-03	- .000	.000	< .137-04	- .104-02
TITANIUM	.427	Q .000	.000	.147	.000	.000	.142-01	.385-03
URANIUM	< .479-02	Q .000	.000	.990-04	- .000	.000	.106-04	- .154-03
VANADIUM	.168-01	Q .000	.000	.439-02	- .000	.000	.626-03	- .000
ZINC	.479-02	Q .000	.000	.282-02	.304-02	.000	.495-03	.121-02
ZIRCONIUM	.671-01	Q .000	.000	.593-02	< .109-03	.000	.162-02	< .193-02
ANIONS								
CHLORIDE	* .000	Q .000	.000	.332-02	* .000	.000	.447-03	* .000
FLUORIDE	* .000	Q .000	.000	.490-02	* .000	.000	.530-03	* .000
CYANIDE	* .000	Q .000	.000	< .129-04	* .000	.000	< .178-05	* .000
NITRATE	* .000	Q .000	.000	< .618-03	* .000	.000	.346-03	* .000
SULFATE	* .000	Q .000	.000	.385-01	* .000	.000	.166-01	* .000
AMMONIUM	* .000	Q .000	.000	.141-03	* .000	.000	.224-03	* .000

APPENDIX D-2
TRACE ELEMENT FLOW RATES
(micrograms per joule)

TRACE ELEMENT MASS FLOWRATE (MCG/JOULE) - BASELINE

TRACE ELEMENTS CATIONS		STREAM LOCATION							
		COAL	BOTTOM ASH	MECHANICAL HOPPER ASH	INLET FLYASH	INLET VAPOR	ESP HOPPER ASH	OUTLET FLYASH	OUTLET VAPOR
ANTIMONY	.114-04	< .447-05	< .137-04	< .518-05	.212-05	< .347-05	.127-05	< .196-05	
ARSENIC	.137-03	.597-05	.182-03	.178-03	.641-05	.150-03	.523-04	< .165-05	
BARIUM	.457-02	.358-02	.137-01	.413-02	.000	.324-02	.801-03	< .184-03	
BERYLLIUM	.533-04	.149-04	.456-04	.178-04	< .277-06	.139-04	.523-05	< .568-05	
BISMUTH	< .190-05	< .104-03	< .319-03	< .983-04	< .554-05	< .810-04	< .159-04	< .398-04	
BORON	< .380-04	< .239-04	.456-03	* .000	.155-03	< .185-04	* .000	< .921-05	
CADMIUM	< .152-04	< .447-05	< .137-04	< .421-05	< .277-06	< .347-05	< .683-06	< .125-05	
CHROMIUM	.969-03	.239-03	.775-03	.295-03	.731-03	.208-03	.645-04	< .541-03	
CORAL T	.327-03	.154-03	.274-03	.112-03	.186-04	.695-04	.142-04	< .278-04	
COPPER	.913-03	.115-03	.524-03	.239-03	.246-03	.185-03	.469-04	< .566-04	
IRON	.243	.143	.356	.858-01	.321-02	.718-01	.137-01	< .256-02	
LEAD	< .533-03	< .447-04	< .137-03	.851-04	.150-04	.695-04	.263-04	< .144-04	
MANGANESE	.647-03	.418-03	.867-03	.305-03	.410-04	.232-03	.532-04	< .344-04	
MERCURY	.190-05	.298-07	.912-07	.179-06	.425-05	.695-07	.923-07	< .608-06	
MOLYBDENUM	.228-04	< .104-03	< .319-03	< .105-03	.111-03	.104-03	.250-04	< .519-04	
NICKEL	.495-03	.969-04	.296-03	.138-03	.471-03	.104-03	.280-04	< .273-03	
SELENIUM	.145-03	< .298-05	< .912-05	< .281-05	.398-05	.347-05	.100-05	< .268-05	
TELLURIUM	< .380-04	< .298-04	< .274-04	< .290-04	.000	< .695-05	< .137-05	< .379-05	
THALLIUM	< .380-04	< .746-06	< .228-05	< .562-05	.000	< .578-06	< .910-06	< .184-05	
TIN	< .533-02	< .149-05	.912-05	.265-04	- .000	< .116-05	< .228-05	< .387-05	
TITANIUM	.248-01	.137-01	.447-01	.135-01	.000	.113-01	.219-02	- .000	
URANIUM	< .190-07	.895-05	.274-04	< .702-05	- .000	.695-05	< .141-05	< .553-05	
VANADIUM	.137-02	.254-03	.109-02	.413-03	- .000	.347-03	.741-04	< .368-04	
ZINC	.799-03	.552-04	.360-03	.286-03	.526-03	.208-03	.721-04	< .829-04	
ZIRCONIUM	< 1.14	.626-03	< .456-04	.475-03	< .831-05	< .116-04	.514-04	< .505-04	
ANIONS									
CHLORIDE	* .000	.149-03	.638-03	.327-03	* .000	.695-04	.952-04	.000	
FLUORIDE	* .000	.179-04	.128-03	.544-04	* .000	.544-04	.500-04	.000	
CYANIDE	* .000	< .149-06	< .456-04	< .151-05	* .000	< .116-06	< .455-06	.000	
NITRATE	* .000	< .298-05	< .912-05	< .518-05	* .000	< .232-05	< .137-05	.000	
SULFATE	* .000	.746-03	.775-02	.679-02	* .000	.602-02	.234-02	.000	
AMMONIUM	* .000	< .149-05	< .456-05	< .237-05	* .000	.706-04	< .190-05	.000	

TRACE ELEMENT MASS FLOWRATE (MCG/JOULE) - BOOS1

TRACE ELEMENTS		STREAM LOCATION						
CATIONS	COAL	BOTTOM ASH	MECHANICAL HOPPER ASH	INLET FLYASH	INLET VAPOR	ESP HOPPER ASH	OUTLET FLYASH	OUTLET VAPOR
ANTIMONY	< .745-04	< .430-05	< .155-04	< .203-05	.362-06	< .971-06	.186-05	.529-05
ARSENIC	.521-04	.717-05	.206-03	.603-04	.535-05	.421-04	.345-04	.135-04
BARIUM	.335-02	.387-02	.516-01	.191-02	.000	.368-02	.407-03	.407-03
BERYLLIUM	.261-04	.143-04	.568-04	.665-05	< .299-06	.421-05	.518-05	< .232-04
BISMUTH	< .186-04	< .100-03	< .361-03	< .404-04	< .578-05	< .226-04	< .186-04	< .134-03
BORON	.335-02	< .230-04	.671-03	* .000	.249-03	< .518-05	* .000	.687-03
CADMILM	< .112-04	< .430-06	< .155-04	< .173-05	< .289-06	< .971-06	< .795-06	< .796-05
CHROMIUM	.559-03	.244-03	.826-03	.137-03	.414-03	.615-04	.795-04	.734-03
CORALT	.186-03	.717-04	.413-03	.396-04	.136-04	.259-04	.239-04	.617-04
COPPER	.745-03	.123-03	.558-03	.120-03	.237-04	.489-04	.976-04	.602-04
IRON	.495	.143	.372	.354-01	.216-02	.207-01	.138-01	.360-02
LEAD	.149-03	< .430-04	< .155-03	.435-04	< .289-05	.259-04	.663-04	.551-04
MANGAEESE	.115-02	.330-03	.671-03	.110-03	.283-04	.582-04	.557-04	.503-04
MERCURY	.968-05	.115-06	.206-06	.103-06	.145-05	.356-07	.292-07	.127-04
MOLYBDENUM	< .559-03	< .100-03	< .361-03	< .473-04	.578-04	< .226-04	.212-04	.265-03
NICKEL	.633-03	.933-04	.336-03	.708-04	.249-03	.291-04	.371-04	.362-03
SELENIUM	< .186-04	< .287-05	< .103-04	< .115-05	.607-04	.971-06	.265-05	.102-05
TELLURIUM	< .372-04	< .861-05	< .310-04	.127-04	.000	.226-05	.159-04	.254-05
THALLIUM	< .745-04	< .717-06	< .258-05	< .231-05	.000	< .162-06	< .159-05	.711-04
TIN	< .745-04	.430-05	.155-04	< .577-05	- .000	< .971-06	< .398-05	- .277-03
TITANIUM	.428-01	.131-01	.537-01	.530-02	.000	.307-02	.180-02	.432-04
URANILM	< .372-03	.100-04	< .258-04	< .289-05	- .000	.324-05	.186-05	- .127-04
VANADIUM	.179-02	.273-03	.124-02	.168-03	- .000	.971-04	.422-04	- .000
ZINC	.633-03	.617-04	.475-03	.122-03	.454-04	.647-04	.848-04	.173-03
ZIRCONIUM	.447-02	.574-03	.671-03	.391-03	.694-04	.210-04	.571-03	.203-03
ANIONS								
CHLORIDE	* .000	.201-03	.878-03	.125-03	* .000	.171-04	.125-02	* .000
FLUORIDE	* .000	.172-04	.619-04	.708-04	* .000	.388-04	.955-04	* .000
CYANIDE	* .000	< .267-05	< .516-06	< .631-06	* .000	< .324-07	< .530-06	* .000
NITRATE	* .000	.617-03	< .103-04	< .175-05	* .000	< .647-06	.424-03	* .000
SULFATE	* .000	< .143-06	.377-02	.230-02	* .000	.165-02	.106-02	* .000
AMMONIUM	* .000	.430-05	.568-04	.183-05	* .000	.123-04	.663-04	* .000

TRACE ELEMENT MASS FLOWRATE (MCG/JOULE) - ROOS 2

TRACE ELEMENTS CATIONS	STREAM LOCATION							
	COAL	BOTTOM ASH	MECHANICAL HOPPER ASH	INLET FLYASH	INLET VAPOR	ESP HOPPER ASH	OUTLET FLYASH	OUTLET VAPOR
ANTIMONY	.226-04	< .418-05	< .130-04	< .480-05	.103-06	< .321-05	< .639-06	< .395-05
ARSENIC	.196-03	.697-05	.174-03	.129-03	.565-05	.128-03	.271-04	< .312-05
BARIUM	.600-02	.363-02	.126-01	.774-02	.000	.310-02	.543-03	< .365-03
BERYLLIUM	.377-04	.139-04	.522-04	.174-04	< .298-06	.139-04	.271-05	< .113-04
BISMUTH	< .189-05	< .976-04	< .304-03	< .861-04	< .597-05	< .749-04	< .112-04	.951-04
BORON	< .377-04	< .223-04	.696-03	* .000	.406-03	< .171-04	* .000	< .345-03
CADMIUM	< .151-04	< .418-05	< .130-04	< .369-05	< .298-06	< .321-05	< .479-06	< .257-05
CHROMIUM	.143-02	.223-03	.826-03	.300-03	.776-03	.214-03	.623-04	< .833-03
COBALT	.641-03	.697-04	.261-03	.109-03	.170-04	.749-04	.192-04	< .505-04
COPPER	.754-03	.116-03	.583-03	.227-03	.418-03	.209-03	.527-04	< .684-04
IRON	.400	.124	.330	.753-01	.358-02	.610-01	.862-02	< .348-02
LEAD	< .528-03	< .418-04	< .130-03	.919-04	.298-04	.749-04	.192-04	< .293-04
MANGANESE	.143-02	.237-03	.609-03	.196-03	.498-04	.171-03	.287-04	< .418-04
MERCURY	.339-05	.976-07	.870-07	.123-06	.696-05	.171-06	.551-07	.124-05
MOLYBDENUM	.109-03	< .976-04	< .304-03	< .999-04	.895-04	< .856-04	.208-04	< .341-03
NICKEL	.136-02	.837-04	.304-03	.149-03	.507-03	.107-03	.335-04	< .561-03
SELENIUM	.143-03	< .279-05	< .870-05	< .246-05	.836-05	.321-05	.192-05	< .000
TELLURIUM	< .377-04	.112-04	< .261-04	.504-04	.000	< .642-05	< .112-05	< .756-05
THALLIUM	< .377-04	< .697-06	< .217-05	< .492-05	.000	< .535-06	< .799-06	< .365-05
TIN	< .528-02	< .139-05	< .435-05	< .123-04	- .000	< .107-05	< .192-05	< .766-05
TITANIUM	.413-01	.128-01	.465-01	.118-01	.000	.108-01	.134-02	< .000
URANIUM	< .189-07	< .697-05	.261-04	< .698-05	- .000	.856-05	< .799-06	< .109-04
VANADIUM	.181-02	.237-03	.100-02	.342-03	- .000	.321-03	.591-04	< .729-04
ZINC	.679-03	.432-04	.344-03	.250-03	.477-03	.203-03	.559-04	< .257-03
ZIRCONIUM	< .113-01	.474-03	.609-03	.126-02	< .895-05	< .107-04	.256-03	< .296-04
ANIONS								
CHLORIDE	* .000	.139-03	.391-03	.485-03	* .000	.610-04	.519-03	.000
FLUORIDE	* .000	.167-03	.478-04	.695-04	* .000	.300-04	.431-04	.000
CYANIDE	* .000	< .558-06	< .174-05	< .178-05	* .000	< .107-06	< .479-06	.000
NITRATE	* .000	< .279-05	< .870-05	< .753-05	* .000	< .214-05	.287-03	.000
SULFATE	* .000	.558-03	.565-02	.617-02	* .000	.471-02	.783-03	.000
AMMONIUM	* .000	< .139-05	.870-05	.996-05	* .000	.214-05	.543-04	.000

TRACE ELEMENT MASS FLOWRATE (MCG/JOULE) - RIAS 1

TRACE ELEMENTS CATIONS		STREAM LOCATION						
	COAL	BOTTOM ASH	MECHANICAL HOPPER ASH	INLET FLYASH	INLET VAPOR	ESP HOPPER ASH	OUTLET FLYASH	OUTLET VAPOR
ANTIMONY	< .759-04	< .435-05	< .133-04	< .418-05	.921-07	< .353-05	< .922-06	.190-05
ARSENIC	.379-04	.435-05	.155-03	.133-03	.972-05	.118-03	.273-04	.235-05
BARIUM	.209-02	.290-02	.106-01	.318-02	.000	.376-02	.618-03	.186-03
BERYLLIUM	.341-04	.145-04	.442-04	.193-04	< .305-06	.165-04	.989-05	< .948-05
BISMUTH	< .190-04	< .101-03	< .310-03	< .960-04	< .609-05	< .824-04	< .167-04	< .610-04
BORON	.379-02	< .232-04	.840-03	* .000	.231-03	< .188-04	* .000	.987-04
CADMIUM	< .114-04	< .435-05	.133-04	< .411-05	< .305-06	< .353-05	< .717-06	< .389-05
CHROMIUM	.379-03	.246-03	.708-03	.293-03	.914-03	.224-03	.849-04	.105-03
CORAL	.266-03	.101-03	.265-03	.967-04	.204-04	.706-04	.191-04	.282-04
COPPER	.797-03	.117-03	.464-03	.255-03	.104-03	.191-03	.492-04	.762-04
IRON	.357	.107	.217	.644-01	.435-02	.576-01	.114-01	.734-03
LEAD	.190-03	< .435-04	.133-03	.987-04	.609-05	.894-04	.507-04	< .221-04
MANGANESE	.110-02	.290-03	< .575-03	.207-03	.670-04	.186-03	.424-04	.575-05
MERCURY	.835-05	.116-06	.177-06	.169-06	.153-05	.176-06	.212-07	.110-05
MOLYBDENUM	< .565-03	< .101-03	< .310-03	< .973-04	.609-04	< .824-04	< .198-04	- .000
NICKEL	.645-03	.159-03	.243-03	.165-03	.548-03	.118-03	.341-04	.322-03
SELENIUM	< .190-04	< .290-05	.133-04	< .274-05	.274-05	.471-05	.106-05	.186-05
TELLURIUM	< .379-04	< .869-05	< .265-04	.200-04	.000	< .706-05	< .143-05	< .130-05
THALLIUM	< .759-04	< .724-06	< .221-05	< .548-05	.000	< .588-06	< .956-06	.317-04
TIN	< .759-04	< .145-05	.442-05	< .137-04	- .000	< .118-05	< .239-05	- .503-04
TITANIUM	.482-01	.132-01	.438-01	.120-01	.000	.118-01	.203-02	.186-05
URANIUM	< .379-03	< .724-05	< .221-04	< .686-05	- .000	.588-05	.270-05	- .130-04
VANADIUM	.197-02	.261-03	.102-02	.387-03	- .000	.318-03	.820-04	- .000
ZINC	.759-03	.507-04	.279-03	.282-03	.182-03	.200-03	.803-04	.131-03
ZIRCONIUM	.986-02	.478-03	.575-03	.117-03	< .914-05	.765-04	.932-04	< .633-04
ANIONS								
CHLORIDE	* .000	.135-03	.752-03	.230-03	* .000	.824-04	.147-03	* .000
FLUORIDE	* .000	.406-04	.354-04	.215-03	* .000	.624-04	.123-03	* .000
CYANIDE	* .000	< .145-06	< .442-06	< .108-05	* .000	< .118-06	< .106-06	* .000
NITRATE	* .000	< .290-05	< .885-05	< .405-05	* .000	< .235-05	< .947-05	* .000
SULFATE	* .000	.768-03	.442-02	.304-02	* .000	.541-02	.138-02	* .000
AMMONIUM	* .000	< .145-05	.973-04	< .157-05	* .000	.235-05	.263-05	* .000

TRACE ELEMENT MASS FLOWRATE (MCG/JOULE) - BIAS 2

TRACE ELEMENTS		STREAM LOCATION						
CATIONS	COAL	BOTTOM ASH	MECHANICAL HOPPER ASH	INLET FLYASH	INLET VAPOR	ESP HOPPER ASH	OUTLET FLYASH	OUTLET VAPOR
ANTIMONY	< .716-04	Q .000	.000	< .198-05	.123-06	.000	.979-06	.291-05
ARSENIC	.111-03	Q .000	.000	.566-04	.399-05	.000	.200-04	.101-04
BARIUM	.447-02	Q .000	.000	.156-02	.000	.000	.479-03	.374-03
BERYLLIUM	.322-04	Q .000	.000	.945-05	< .271-06	.000	.282-05	< .203-04
BISMUTH	< .179-04	Q .000	.000	< .385-04	< .542-05	.000	< .108-04	< .124-03
BORON	.322-02	Q .000	.000	* .000	.558-03	.000	* .000	.453-03
CADMIUM	< .107-04	Q .000	.000	< .165-05	< .271-06	.000	< .465-06	.134-04
CHROMIUM	.537-03	Q .000	.000	.141-03	.734-03	.000	.534-04	.381-03
CORALIT	.179-03	Q .000	.000	.498-04	.181-04	.000	.160-04	.503-04
COPPER	.823-03	Q .000	.000	.130-03	.813-04	.000	.447-04	.497-04
IRON	.369	Q .000	.000	.296-01	.360-02	.000	.852-02	.187-02
LEAD	.179-03	Q .000	.000	.510-04	.542-05	.000	.245-04	< .446-04
MANGANESE	.608-03	Q .000	.000	.777-04	.526-04	.000	.275-04	.269-04
MERCURY	.104-04	Q .000	.000	.412-06	.000	.000	.290-07	.833-06
MOLYBDENUM	< .537-03	Q .000	.000	< .403-04	.542-04	.000	< .170-04	.249-03
NICKEL	.465-03	Q .000	.000	.722-04	.406-03	.000	.251-04	.200-03
SELENIUM	< .179-04	Q .000	.000	< .113-05	.217-05	.000	.124-05	.458-06
TELLURIUM	< .358-04	Q .000	.000	.369-04	.000	.000	< .930-06	.287-05
THALLIUM	< .716-04	Q .000	.000	< .220-05	.000	.000	< .820-06	.661-04
TIN	< .716-04	Q .000	.000	.133-04	.000	.000	< .155-05	.776-04
TITANIUM	.318-01	Q .000	.000	.567-02	.000	.000	.160-02	.287-04
URANIUM	< .358-03	Q .000	.000	.382-05	.000	.000	.120-05	.115-04
VANADIUM	.125-02	Q .000	.000	.170-03	.000	.000	.707-04	.000
ZINC	.358-03	Q .000	.000	.109-03	.227-03	.000	.559-04	.904-04
ZIRCONIUM	.501-02	Q .000	.000	.229-03	< .813-05	.000	.183-03	< .144-03
ANIONS								
CHLORIDE	* .000	Q .000	.000	.128-03	* .000	.000	.505-04	* .000
FLUORIDE	* .000	Q .000	.000	.189-03	* .000	.000	.374-04	* .000
CYANIDE	* .000	Q .000	.000	< .498-06	* .000	.000	< .201-06	* .000
NITRATE	* .000	Q .000	.000	< .316-04	* .000	.000	.591-04	* .000
SULFATE	* .000	Q .000	.000	.149-02	* .000	.000	.188-02	* .000
AMMONIUM	* .000	Q .000	.000	.544-05	* .000	.000	.253-04	* .000

TRACE ELEMENT FLOW RATES
(micrograms per dry standard cubic meter)

TRACE ELEMENT ANALYSIS - (MCG/OSCM) -
10 & 3 MICRON CYCLONES

TRACE ELEMENTS	CATIONS	BASELINE	TEST CONDITION			
			BOOS 1	BOOS 2	BIAS 1	BIAS 2
TRACE ELEMENTS	ANTIMONY	< 9.19	< 3.55	< 7.54	< 11.2	< 4.98
	ARSENIC	276.	113.	239.	355.	166.
	BARIUM	.858+04	.379+04	.178+05	.859+04	.464+04
	BERYLLIUM	56.0	13.0	3.7	52.3	28.2
	BISMUTH	< 214.	< 82.9	< 176.	< 261.	< 116.
	BORON	* .000	* .000	* .000	* .000	* .000
	CADMIUM	< 9.19	< 3.55	< 7.54	< 11.2	< 4.98
	CHROMIUM	552.	249.	578.	784.	415.
	CORAL	245.	71.1	201.	261.	149.
	COPPER	484.	242.	402.	697.	388.
TRACE ELEMENTS	IRON	.190+06	.734+05	.158+06	.175+06	.896+05
	LEAD	123.	71.1	126.	261.	149.
	MANGANESE	643.	213.	377.	560.	232.
	MERCURY	.398	.130	.251	.448	1.29
	MOLYBDENUM	< 214.	< 82.9	< 176.	< 261.	< 116.
	NICKEL	276.	136.	276.	448.	216.
	SELENIUM	< 6.13	< 2.37	< 5.02	< 7.47	< 3.32
	TELLURIUM	< 18.4	< 11.8	< 126.	< 56.0	< 116.
	THALLIUM	< 12.3	< 4.74	< 10.0	< 14.9	< 6.63
	TIN	61.3	< 11.8	< 25.1	< 37.3	< 41.5
TRACE ELEMENTS	TITANIUM	.294+05	.108+05	.241+05	.325+05	.171+05
	URANIUM	< 15.3	< 5.92	< 12.6	< 18.7	< 11.6
	VANADIUM	797.	320.	603.	.105+04	498.
	ZINC	490.	201.	352.	747.	315.
	ZIRCONIUM	.113+04	675.	.527+04	299.	647.
ANIONS	CHLORIDE	490.	142.	804.	635.	265.
	FLUORIDE	101.	26.1	103.	597.	580.
	CYANIDE	< 2.45	< .829	< 2.51	< 2.99	< 1.49
	NITRATE	< 9.19	< 2.37	< 12.6	< 11.2	< 4.98
	SULFATE	.126+05	.355+04	.955+04	.709+04	.431+04
	AMMONIUM	< 3.06	3.55	22.6	< 3.73	9.95

TRACE ELEMENT ANALYSIS - (MCG/DSCM) - ROILER OUTLET ASH
1 MICRON & FILTER

TRACE ELEMENTS	TEST CONDITION				
	CATIONS	BASELINE	BOOS1	BOOS 2	BIAS 1
ANTIMONY	ANTIMONY	5.44	1.47	5.10	.772
	ARSENIC	227.	36.7	102.	27.0
	BARIUM	.309+04	929.	.255+04	521.
	BERYLLIUM	13.6	3.42	13.1	3.09
	BISMUTH	< 63.5	< 17.1	< 51.0	< 13.5
BORON	BORON	* .000	* .000	* .000	* .000
	CADMIUM	< 2.72	< .733	< 2.19	< .579
	CHROMIUM	281.	90.4	211.	35.4
	CORALY	72.6	26.9	67.5	15.4
	COPPER	192.	55.0	195.	42.5
IRON	IRON	.526+05	.142+05	.401+05	.907+04
	LEAD	118.	36.7	117.	21.2
	MANGANESE	218.	58.7	139.	32.8
	MEPCURY	.109	.125	.729-01	.367-01
	MOLYBDENUM	81.7	34.2	87.5	17.4
NICKEL	NICKEL	113.	39.1	117.	25.1
	SELENIUM	< 1.81	< .489	< 1.46	< .386
	TELLURIUM	< 63.5	< 19.6	< 7.29	< 1.16
	THALLIUM	< 3.63	< .978	< 2.92	< .772
	TIN	13.6	2.44	< 7.29	< 1.93
TITANIUM	TITANIUM	.871+04	.235+04	.700+04	.178+04
	URANIUM	4.54	1.22	5.83	.965
	VANADIUM	372.	95.3	299.	63.7
	ZINC	318.	100.	306.	59.8
	ZIRCONIUM	209.	293.	54.7	36.7
ANTIONS	CHLORIDE	436.	166.	474.	25.1
	FLUORIDE	52.6	149.	80.2	18.5
	CYANIDE	< 1.81	< .733	< 2.19	< .945-01
	NITRATE	< 5.44	< 1.96	< 7.29	< .386
	SULFATE	.662+04	.215+04	.671+04	.162+04
AMMONIUM	AMMONIUM	< 3.63	< .978	< 3.65	.772
					7.37

TRACE ELEMENT ANALYSIS - (MCG/DSCM) - BOILER OUTLET ASH
XAD-2 CARTRIDGE

TRACE ELEMENTS	TEST CONDITION					
	CATIONS	BASELINE	BOOS1	BOOS 2	BIAS 1	BIAS 2
	ANTIMONY	N .000	N .000	N .000	N .000	N .000
	ARSENIC	N .000	N .000	N .000	N .000	N .000
	BARIUM	N .000	N .000	N .000	N .000	N .000
	BERYLLIUM	N .000	N .000	N .000	N .000	N .000
	BISMUTH	N .000	N .000	N .000	N .000	N .000
	BORON	N .000	N .000	N .000	N .000	N .000
	CADMIUM	N .000	N .000	N .000	N .000	N .000
	CHROMIUM	N .000	N .000	N .000	N .000	N .000
	CORAL	N .000	N .000	N .000	N .000	N .000
	COPPER	N .000	N .000	N .000	N .000	N .000
	IRON	N .000	N .000	N .000	N .000	N .000
	LEAD	N .000	N .000	N .000	N .000	N .000
	MANGANESE	N .000	N .000	N .000	N .000	N .000
	MERCURY	N .000	N .000	N .000	N .000	N .000
	MOLYBDENUM	N .000	N .000	N .000	N .000	N .000
	NICKEL	N .000	N .000	N .000	N .000	N .000
	SELENIUM	N .000	N .000	N .000	N .000	N .000
	TELLURIUM	N .000	N .000	N .000	N .000	N .000
	THALLIUM	N .000	N .000	N .000	N .000	N .000
	TIN	N .000	N .000	N .000	N .000	N .000
	TITANIUM	N .000	N .000	N .000	N .000	N .000
	URANIUM	N .000	N .000	N .000	N .000	N .000
	VANADIUM	N .000	N .000	N .000	N .000	N .000
	ZINC	N .000	N .000	N .000	N .000	N .000
	ZIRCONIUM	N .000	N .000	N .000	N .000	N .000
ANIONS	CHLORIDE	N .000	N .000	N .000	N .000	N .000
	FLUORIDE	N .000	N .000	N .000	N .000	N .000
	CYANIDE	N .000	N .000	N .000	N .000	N .000
	NITRATE	N .000	N .000	N .000	N .000	N .000
	SULFATE	N .000	N .000	N .000	N .000	N .000
	AMMONIUM	N .000	N .000	N .000	N .000	N .000

TRACE ELEMENT ANALYSIS - (MCG/DSCM) - BOILER OUTLET ASH
FIRST IMPINGER

TRACE ELEMENTS	CATIONS	BASELINE	TEST CONDITION			BIAS 1	BIAS 2
			BOOS1	BOOS 2			
D-20	ANTIMONY	.000	.000	.000		.000	.000
	ARSENIC	17.2	10.7	14.2		25.3	10.4
	BARIUM	.000	.000	.000		.000	.000
	BERYLLIUM	<	<	<	<	.872	.863
	BISMUTH	<	<	<	<	17.4	17.3
	BORON	438.	615.	.107+04		663.	.178+04
	CADMIUM	<	<	<	<	.872	.863
	CHROMIUM	.207+04	.102+04	.205+04		.262+04	.234+04
	COPALT	52.5	33.6	44.8		58.4	57.8
	COPPER	697.	58.7	.110+04		296.	259.
	IRON	.908+04	.534+04	.944+04		.125+05	.115+05
	LEAD	42.3	7.15	78.7		17.4	17.3
	MANGANESE	116.	70.1	131.		192.	167.
	MERCURY	.000	.000	.000		.000	.000
	MOLYBDENUM	313.	143.	236.		174.	175.
	NICKEL	.133+04	615.	.134+04		.157+04	.129+04
	SELENIUM	11.0	150.	22.0		7.45	6.91
	TELLURIUM	.000	.000	.000		.000	.000
	THALLIUM	.000	.000	.000		.000	.000
	TIN	.000	.000	.000		.000	.000
	TITANIUM	.000	.000	.000		.000	.000
	URANIUM	.000	.000	.000		.000	.000
	VANADIUM	.000	.000	.000		.000	.000
	ZINC	.149+04	112.	.126+04		520.	722.
	ZIRCONIUM	<	172.	<	<	26.2	25.9
ANIONS	CHLORIDE	* .000	* .000	* .000	*	.000	.000
	FLUORIDE	* .000	* .000	* .000	*	.000	.000
	CYANIDE	* .000	* .000	* .000	*	.000	.000
	NITRATE	* .000	* .000	* .000	*	.000	.000
	SULFATE	* .000	* .000	* .000	*	.000	.000
	AMMONIUM	* .000	* .000	* .000	*	.000	.000

TRACE ELEMENT ANALYSIS - (MCG/DSCM) - BOILER OUTLET ASH
2ND & 3RD IMPINGERS

TRACE ELEMENTS	CATIONS	BASELINE	TEST CONDITION			
			BOOS1	BOOS 2	BIAS 1	BIAS 2
ANTIMONY	ARSENIC	6.01	.895	.271	.264	.391
	BARIUM	.901	2.51	.723	2.55	2.54
	BERYLLIUM	.000	*	.000	.000	.000
	BISMUTH	.000	*	.000	.000	.000
	BORON	.000	*	.000	.000	.000
CADIUM	CHROMIUM	.000	*	.000	.000	.000
	COBALT	.000	*	.000	.000	.000
	COPPER	.000	*	.000	.000	.000
	IRON	.000	*	.000	.000	.000
	LEAD	.000	*	.000	.000	.000
MANGANESE	MERCURY	.000	*	.000	.000	.000
	MOLYBDENUM	12.0	3.58	16.1	4.39	.000
	NICKEL	.000	*	.000	.000	.000
	SELENIUM	.000	*	.000	.000	.000
	TELLURIUM	.000	*	.000	.000	.000
THALLIUM	TIN	.000	*	.000	.000	.000
	TITANIUM	.000	*	.000	.000	.000
	URANIUM	.000	*	.000	.000	.000
	VANADIUM	.000	*	.000	.000	.000
	ZINC	.000	*	.000	.000	.000
ZIRCONIUM	CHLORIDE	.000	*	.000	.000	.000
	FLUORIDE	.000	*	.000	.000	.000
	CYANIDE	.000	*	.000	.000	.000
	NITRATE	.000	*	.000	.000	.000
	SULFATE	.000	*	.000	.000	.000
ANIONS	AMMONIUM	.000	*	.000	.000	.000

TRACE ELEMENT ANALYSIS - (MCG/DSCM) - BOILER OUTLET ASH

TRACE ELEMENTS		TEST CONDITION			
CATIONS	BASLINE	BOOS1	BOOS 2	BIAS 1	BIAS 2
ANTIMONY	< 20.6	< 5.91	< 12.9	< 12.2	< 6.71
ARSENIC	521.	162.	356.	409.	193.
BARIUM	.117+05	.472+04	.204+05	.911+04	.496+04
BERYLLIUM	51.2	17.2	46.6	56.2	31.0
BISMUTH	< 294.	< 114.	< 243.	< 292.	< 140.
BORON	438.	615.	.107+04	663.	.178+04
CADMIUM	< 12.7	< 5.00	< 10.5	< 12.6	< 6.13
CHROMIUM	.290+04	.136+04	.283+04	.345+04	.279+04
CORALIT	370.	132.	333.	335.	217.
COPPER	.137+04	355.	.170+04	.103+04	674.
IRON	.252+06	.929+05	.208+06	.197+06	.106+06
LEAD	283.	115.	321.	300.	180.
MANGANESE	977.	342.	647.	785.	415.
MERCURY	12.5	3.83	18.4	4.88	1.31
MOLYBDENUM	< 609.	< 260.	< 499.	< 453.	< 301.
NICKEL	.172+04	791.	.173+04	.204+04	.152+04
SELENIUM	< 18.9	< 153.	< 28.5	< 15.7	< 10.5
TELLURIUM	< 81.9	31.4	133.	57.2	118.
THALLIUM	< 15.9	< 5.72	< 15.0	< 15.7	< 7.02
TIN	74.9	< 14.3	< 32.4	< 39.3	42.4
TITANIUM	.381+05	.131+05	.311+05	.343+05	.181+05
URANIUM	< 19.9	< 7.14	< 10.4	< 19.6	12.2
VANADIUM	.117+04	415.	902.	.111+04	541.
ZINC	.230+04	414.	.191+04	.133+04	.107+04
ZIRCONIUM	.137+04	.114+04	.534+04	361.	756.
ANIONS					
CHLORIDE	926.	308.	.128+04	660.	409.
FLUORIDE	154.	175.	183.	616.	602.
CYANIDE	< 4.27	< 1.56	< 4.70	< 3.08	< 1.59
NITRATE	< 14.6	< 4.32	< 19.9	< 11.6	< 103.
SULFATE	.192+05	.570+04	.163+05	.871+04	.474+04
AMMONIUM	< 6.69	4.53	26.3	< 4.50	17.3

TRACE ELEMENT ANALYSIS - (HCG/DSCM) - FLYASH OUTLET
10 & 3 MICRON CYCLONES

TRACE ELEMENTS	BASELINE	TEST CONDITION				BIAS 1	BIAS 2
		POOS1	BOOS 2				
CATIONS							
ANTIMONY	1.29	N .000	N .000			1.15	1.52
ARSENIC	33.5	N .000	N .000			36.3	31.8
BARIUM	876.	N .000	N .000			842.	795.
BERYLLIUM	3.35	N .000	N .000			5.74	4.24
BISMUTH	18.0	N .000	N .000			26.8	18.5
BORON	.000	N .000	N .000		*	.000	.000
CADMIUM	.773	N .000	N .000			1.15	.795
CHROMIUM	59.2	N .000	N .000			95.6	71.5
CORALIT	20.6	N .000	N .000			30.6	23.8
COPPER	47.9	N .000	N .000			70.0	68.9
IRON	.152+05	N .000	N .000			.176+05	.146+05
LEAD	20.6	N .000	N .000			34.4	29.1
MANGANESE	54.1	N .000	N .000			61.2	42.4
MERCURY	.335-.01	N .000	N .000			.306-.01	.530-.01
MOLYBDENUM	20.6	N .000	N .000			26.8	18.5
NICKEL	27.0	N .000	N .000			55.5	37.1
SELENIUM	1.29	N .000	N .000			1.53	2.12
TELLURIUM	1.55	N .000	N .000			2.30	1.59
THALLIUM	1.03	N .000	N .000			1.53	1.06
TIN	2.58	N .000	N .000			3.83	2.65
TITANIUM	.245+04	N .000	N .000			.325+04	.270+04
URANIUM	1.29	N .000	N .000			3.83	1.59
VANADIUM	92.7	N .000	N .000			103.	95.4
ZINC	54.1	N .000	N .000			95.6	68.9
ZIRCONIUM	59.2	N .000	N .000			149.	477.
ANIONS							
CHLORIDE	111.	N .000	N .000			184.	98.0
FLUORIDE	30.9	N .000	N .000			291.	84.8
CYANIDE	.515	N .000	N .000			.153	.530
NITRATE	1.55	N .000	N .000			2.68	71.5
SULFATE	.201+04	N .000	N .000			.203+04	.241+04
AMMONIUM	.773	N .000	N .000			1.91	25.4

TRACE ELEMENT ANALYSIS - (MCG/USCM) - FLYASH OUTLET
1 MICKON & FILTER

TRACE ELEMENTS

TEST CONDITION

CATIONS	BASELINE	BOOS1	BOOS 2	BIAS 1	BIAS 2
ANTIMONY	2.26	4.50	< 1.71	1.44	1.66
ARSENIC	56.5	83.6	72.7	40.3	29.0
BARIUM	.136+04	.148+04	.145+04	892.	662.
BERYLLIUM	5.65	7.71	7.27	5.16	4.35
BISMUTH	< 26.4	< 45.0	< 29.9	< 20.1	< 14.5
BORON	* .000	* .000	* .000	* .000	* .000
CADMIUM	< 1.13	< 1.93	< 1.28	< .863	< .621
CHROMIUM	121.	193.	167.	86.3	91.1
CORALT	18.6	57.9	51.3	23.0	24.8
COPPER	82.9	237.	141.	67.9	67.3
IRON	.230+05	.334+05	.231+05	.144+05	.114+05
LEAD	52.8	161.	51.3	51.8	45.5
MANGANESE	94.2	135.	76.9	57.5	41.4
MERCURY	.565-01	.707-01	.540-01	.288-01	.352-01
MOLYBDCENUM	49.0	51.4	55.6	28.8	33.1
NICKEL	50.9	90.0	89.8	40.3	39.3
SELENIUM	1.51	6.43	5.13	1.44	1.66
TELLURIUM	< 2.26	38.6	2.99	< 1.73	< 1.24
THALLIUM	< 1.51	< 3.86	< 2.14	< 1.15	< .828
TIN	< 3.77	< 9.64	< 5.13	< 2.80	< 2.07
TITANIUM	.366+04	.437+04	.359+04	.244+04	.217+04
URANIUM	2.64	4.50	2.14	3.74	2.07
VANADIUM	170.	199.	158.	127.	120.
ZINC	147.	206.	150.	129.	101.
ZIRCONIUM	< 28.3	900.	684.	112.	80.7
ANIONS					
CHLORIDE	155.	.302+04	855.	227.	55.9
FLUORIDE	52.8	231.	115.	54.6	29.0
CYANIDE	< .754	< 1.29	< 1.28	.144	< .828-01
NITRATE	< 2.26	.103+04	769.	23.9	47.6
SULFATE	.752+04	.257+04	.209+04	.184+04	.331+04
AMMONIUM	4.52	161.	145.	5.46	51.8

TRACE ELEMENT ANALYSIS - (MCG/DSCM) - FLYASH OUTLET
XAD-2 CARTRIDGE

TRACE ELEMENTS	CATIONS	BASELINE	TEST CONDITION			
			ROOS1	ROOS 2	BIAS 1	BIAS 2
ANTIMONY	<	5.14	<	9.76	<	5.22
	<	.000	<	.000	<	8.75
	<	514.	<	976.	<	26.3
	<	15.4	<	29.3	<	.114+04
	<	103.	<	234.	<	61.3
BORON	<	25.7	<	48.8	<	368.
	<	3.08	<	5.85	<	420.
	<	.000	<	.000	<	26.3
	<	51.4	<	97.6	<	.000
	<	.000	<	.000	<	131.
IRON	<	407.	<	.000	<	35.0
	<	117.	<	68.3	<	201.
	<	.000	<	.000	<	131.
	<	1.69	<	3.42	<	.000
	<	61.6	<	97.6	<	2.54
NICKEL	<	97.6	<	78.1	<	665.
	<	.000	<	.000	<	96.3
	<	10.3	<	19.5	<	.000
	<	5.14	<	9.76	<	8.75
	<	10.8	<	20.5	<	201.
TITANIUM	<	105.	<	.000	<	236.
	<	30.8	<	29.3	<	87.5
	<	.000	<	195.	<	35.0
	<	41.1	<	39.0	<	.000
	<	128.	<	48.8	<	184.
ZINC	<	.000	<	.000	<	438.
	<	103.	<	.000	<	.000
	<	41.1	<	.000	<	.000
	<	128.	<	.000	<	.000
	<	.000	<	.000	<	.000
ZIRCONIUM	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
ANIONS	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
CHLORIDE	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
FLUORIDE	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
CYANIDE	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
NITRATE	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
SULFATE	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
AMMONIUM	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000
	<	.000	<	.000	<	.000

TRACE ELEMENT ANALYSIS - (MCG/DSCM) - FLYASH OUTLET
FIRST IMPINGER

TRACE ELEMENTS	CATIONS	BASELINE	TEST CONDITION			
			BOOS1	BOOS 2	BIAS 1	BIAS 2
CATIONS	ANTIMONY	.249	.494	.014	*	.000
	ARSENIC	4.15	7.41	6.10	*	.000
	BARIUM	.000	.000	.000	<	.000
	BERYLLIUM	.415	.823	1.02	<	.460
	BISMUTH	< 8.31	< 16.5	< 20.3	<	9.21
	BORON	.000	.128+04	875.	*	.000
	CADMIUM	.415	.823	1.02	<	.460
	CHROMIUM	.151+04	.178+04	.223+04	295.	15.8
	COBALT	26.2	38.7	37.6	21.6	.116+04
	COPPER	158.	115.	183.	198.	21.9
CATIONS	IRON	.715+04	.831+04	.932+04	.150+04	116.
	LEAD	4.15	16.5	10.2	<	.549+04
	MANGANESE	96.0	122.	112.	16.1	4.65
	MERCURY	.000	28.0	814.	*	81.9
	MOLYBDENUM	83.1	82.3	.000	-	.000
	NICKEL	665.	798.	.142+04	170.	93.1
	SELENIUM	7.48	2.47	.000	*	512.
	TELLURIUM	.291	.000	.712	*	1.40
	THALLIUM	.000	.000	.000	.000	.000
	TIN	.000	.000	.000	.000	.000
CATIONS	TITANIUM	.000	.000	.000	.000	.000
	URANIUM	.000	.000	.000	.000	.000
	VANADIUM	.000	.000	.000	.000	.000
	ZINC	190.	277.	648.	238.	.000
	ZIRCONIUM	< 12.5	98.8	30.5	*	91.7
ANIONS	CHLORIDE	.000	.000	.000	*	1.40
	FLUORIDE	.000	.000	.000	*	.000
	CYANIDE	.000	.000	.000	*	.000
	NITRATE	.000	.000	.000	*	.000
	SULFATE	.000	.000	.000	*	.000
	AMMONIUM	.000	.000	.000	*	.000
					*	.000

TRACE ELEMENT ANALYSIS - (MCG/DSCM) - FLYASH OUTLET
2ND & 3RD IMPINGERS

TRACE ELEMENTS

CATIONS	BASELINE	HOOS1	TEST CONDITION	HOOS2	BIAS 1	BIAS 2
ANTIMONY	.902-01	.000	.000	.000	.115	.122
ARSENIC	.451	.613	2.26	2.26	1.38	1.77
BARIUM	.000	*	.000	.000	.000	.000
BERYLLIUM	.000	*	.000	.000	.000	.000
BISMUTH	.000	*	.000	.000	.000	.000
BORON	.000	*	.000	.000	.000	.000
CADMIUM	.000	*	.000	.000	.000	.000
CHROMIUM	.000	*	.000	.000	.000	.000
COBALT	.000	*	.000	.000	.000	.000
COPPER	.000	*	.000	.000	.000	.000
IRON	.000	*	.000	.000	.000	.000
LEAD	.000	*	.000	.000	.000	.000
MANGANESE	.000	*	.000	.000	.000	.000
MERCURY	.000	*	.000	.000	.000	.000
MOLYBDENUM	.000	*	.000	.000	.000	.000
NICKEL	.000	*	.000	.000	.000	.000
SELENIUM	.000	*	.000	.000	.000	.000
TELLURIUM	.000	*	.000	.000	.000	.000
THALLIUM	.000	*	.000	.000	.000	.000
TIN	.000	*	.000	.000	.000	.000
TITANIUM	.000	*	.000	.000	.000	.000
URANIUM	.000	*	.000	.000	.000	.000
VANADIUM	.000	*	.000	.000	.000	.000
ZINC	.000	*	.000	.000	.000	.000
ZIRCONIUM	.000	*	.000	.000	.000	.000
ANIONS						
CHLORIDE	.000	*	.000	.000	.000	.000
FLUORIDE	.000	*	.000	.000	.000	.000
CYANIDE	.000	*	.000	.000	.000	.000
NITRATE	.000	*	.000	.000	.000	.000
SULFATE	.000	*	.000	.000	.000	.000
AMMONIUM	.000	*	.000	.000	.000	.000

TRACE ELEMENT ANALYSIS - (MCG/DSCM) - FLYASH OUTLET

TRACE ELEMENTS	BASELINE	TEST CONDITION			
		ROOS1	ROOS 2	BIAS 1	BIAS 2
CATIONS					
ANTIMONY	9.02	17.3	< 12.3	< 7.92	11.9
ARSENIC	94.6	116.	- 81.0	83.2	91.6
BARIUM	.275+04	.246+04	< .243+04	.226+04	.259+04
BERYLLIUM	24.8	64.0	< 37.6	37.5	70.3
BISMUTH	155.	< 369.	< 284.	< 218.	410.
BORON	25.7	.167+04	< 94.	277.	.138+04
CADMIUM	5.40	21.2	< 8.15	< 12.9	43.5
CHROMIUM	.169+04	.197+04	- .240+04	477.	.132+04
COBALT	117.	207.	< 187.	133.	202.
COPPER	289.	383.	- 324.	352.	287.
IRON	.453+05	.421+05	- .324+05	.340+05	.317+05
LEAD	113.	294.	< 130.	148.	211.
MANGANESE	244.	257.	- 169.	135.	166.
MERCURY	1.78	30.9	3.51	3.14	2.63
MOLYBDENUM	214.	694.	< 967.	< 55.5	810.
NICKEL	840.	969.	< .159+04	997.	684.
SELENIUM	10.3	8.90	- 5.13	8.19	5.17
TELLURIUM	14.4	44.7	< 23.2	< 7.68	11.6
THALLIUM	7.67	176.	< 11.9	< 91.4	203.
TIN	17.1	681.	< 25.6	< 144.	241.
TITANIUM	.610+04	.448+04	- .359+04	.570+04	.496+04
URANIUM	19.3	35.3	< 31.4	44.1	38.7
VANADIUM	365.	199.	< 353.	230.	215.
ZINC	432.	625.	837.	594.	446.
ZIRCONIUM	228.	.139+04	< 763.	439.	997.
ANIONS					
CHLORIDE	265.	.302+04	855.	411.	154.
FLUORIDE	43.7	231.	145.	345.	114.
CYANIDE	1.27	< 1.29	1.28	< .297	.613
NITRATE	5.81	.103+04	769.	< 26.6	119.
SULFATE	.653+04	.257+04	.209+04	.387+04	.572+04
AMMONIUM	5.30	161.	145.	7.58	77.2